LOWER ARKANSAS RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody: Arkansas River, Wichita to Arkansas City and
Little Arkansas River, Valley Center to Wichita
Water Quality Impairment: Total Phosphorus and pH

1. INTRODUCTION

Subbasin: Middle Arkansas – Slate, Little Arkansas

Counties: Sedgwick, Sumner, Cowley

HUC8: 11030012	**HUC10** (12): **05** (01, 02)
HUC8: 11030010	**HUC10** (12): **02** (08)
HUC8: 11030013	**HUC10** (12): **01** (01, 06) **02** (05, 06) **03** (01, 03, 04, 05, 06, 07, 08)
HUC 8: 11030016	**HUC10** (12): **02** (03)

Ecoregion: Wellington-McPherson Lowland (27d)

Drainage Area: 584 mi^2

Main Stem Water Quality Limited Segments and Tributaries (*designated uses for main stem and tributary segments are detailed in* ***Table 1)*****:**

Main Stem	**Tributaries**
HUC8 11030012	
Little Arkansas River (1)	Chisholm Creek (1693)
	Chisholm Creek, Middle Fork (817)
HUC8 11030013	
Arkansas River (9)	
Arkansas River (3)	Chisholm Creek (8)
	Chisholm Creek, East (7)
	Chisholm Creek (6)
	Gypsum Creek (5)
	Chisholm Creek (4)

Main Stem (continued)	**Tributaries (continued)**
HUC8 11030013 (continued)	
	Spring Creek (37)
	Dog Creek (531)
	Bitter Creek (28)
Arkansas River (18)	
Arkansas River (2)	Lost Creek (23)
	Spring Creek (34)
	Beaver Creek (33)
Arkansas River (1)	Antelope Creek (25)
	Winser Creek (32)
	Salt Creek (22)
	Spring Creek (19)
	Negro Creek (20)
	Spring Creek (21)

Table 1. Designated uses for main stem and tributary segments in the watershed (Kansas Department of Health and Environment, 2013).

Stream	Segment Number	Expected Aquatic Life	Contact Recreation	Domestic Supply	Food Procurement	Ground Water Recharge	Industrial Water Use	Irrigation Use	Livestock Watering Use
HUC 8: 11030012									
Little Arkansas River	***1***	***E***	***B***	***Y***	***Y***	***Y***	***Y***	***Y***	***Y***
Chisholm Creek	1693	E	a	Y	Y	Y	Y	Y	Y
Chisholm Creek, Middle Fk	817	E	b	N	Y	N	N	Y	Y
HUC 8: 11030013									
Arkansas River	***9***	***S***	***B***	***Y***	***Y***	***Y***	***Y***	***Y***	***Y***
Arkansas River	***3***	***S***	***B***	***Y***	***Y***	***Y***	***Y***	***Y***	***Y***
Chisholm Creek	8	E	a	N	Y	Y	Y	Y	Y
Chisholm Creek, East	7	E	B	Y	Y	Y	Y	Y	Y
Chisholm Creek	6	R	a	N	N	N	N	N	N
Gypsum Creek	5	E	B	Y	Y	Y	Y	Y	Y
Chisholm Creek	4	R	a	N	N	N	N	N	N
Spring Creek	37	E	C	N	Y	Y	N	Y	Y
Dog Creek	531	E	b	Y	N	Y	Y	Y	Y
Bitter Creek	28	E	b	Y	Y	Y	Y	Y	Y
Arkansas River	***18***	***S***	***B***	***Y***	***Y***	***Y***	***Y***	***Y***	***Y***
Arkansas River	***2***	***S***	***B***	***Y***	***Y***	***Y***	***Y***	***Y***	***Y***
Lost Creek	23	E	b	N	N	Y	N	Y	Y
Spring Creek	34	E	b	N	N	Y	N	Y	Y
Beaver Creek	33	E	b	Y	Y	Y	Y	Y	Y
Arkansas River	***1***	***S***	***B***	***Y***	***Y***	***Y***	***Y***	***Y***	***Y***
Antelope Creek	25	E	b	Y	Y	Y	Y	Y	Y
Winser Creek	32	E	b	N	Y	Y	N	Y	Y
Salt Creek	22	E	b	N	N	Y	N	Y	Y

Stream	Segment Number	Expected Aquatic Life	Contact Recreation	Domestic Supply	Food Procurement	Ground Water Recharge	Industrial Water Use	Irrigation Use	Livestock Watering Use
HUC 8: 11030013 (continued)									
Spring Creek	19	S	b	Y	N	Y	Y	Y	Y
Negro Creek	20	E	b	N	Y	N	N	N	N
Spring Creek	21	E	b	Y	Y	Y	Y	Y	Y

Y = use is designated; N = use is not designated; E=Expected aquatic life; S=Special Aquatic Life
Contact Recreation: A, B, C=Primary Contact Recreation; a, b=Secondary Contact Recreation

303(d) Listings: Station SC728 (**Figure 1**), Little Arkansas River at Wichita.
Biology TMDL (Cat. 4a): 2002, 2004, 2008, 2010, 2012, 2014, 2016, and 2018.
Total Phosphorus (TP) Impairment (Cat. 5): 2008, 2010, 2012, 2014, 2016 and 2018.
Lower Arkansas River Basin Streams.

Station SC729 (**Figure 2**), Arkansas River at Wichita.
Biology TMDL (Cat. 4a): 2002, 2004, 2008, 2010, 2012, 2014, 2016, and 2018.
Total Phosphorus (TP) Impairment (Cat. 5): 2008, 2010, 2012, 2014, 2016 and 2018.
Lower Arkansas River Basin Streams.

Station SC281 (**Figure 3**), Arkansas River at Derby.
Biology TMDL (Cat. 4a): 2002, 2004, 2008, 2010, 2012, 2014, 2016, and 2018.
Total Phosphorus (TP) Impairment (Cat. 5): 2008, 2010, 2012, 2014, 2016, and 2018.
Lower Arkansas River Basin Streams.

Station SC527 (**Figure 4**), Arkansas River at Oxford.
Total Phosphorus (TP) Impairment (Cat. 5): 2008, 2010, 2012, 2014, 2016, and 2018.
pH Impairment (Cat. 5): 2008, 2010, 2012, 2014, 2016, and 2018.
Lower Arkansas River Basin Streams.

Station SC218 (**Figure 5**), Arkansas River at Arkansas City.
Biology TMDL (Cat. 4a): 2002, 2004, 2008, 2010, 2012, 2014, 2016, and 2018.
Total Phosphorus (TP) Impairment (Cat. 5): 2008, 2010, 2012, 2014, 2016, and 2018.
pH Impairment (Cat. 5): 2002, 2004, 2008, 2010, 2012, 2014, 2016, and 2018.
Lower Arkansas River Basin Streams.

Figure 1. Map of contributing area for KDHE stream chemistry station SC728, Little Arkansas River at Wichita.

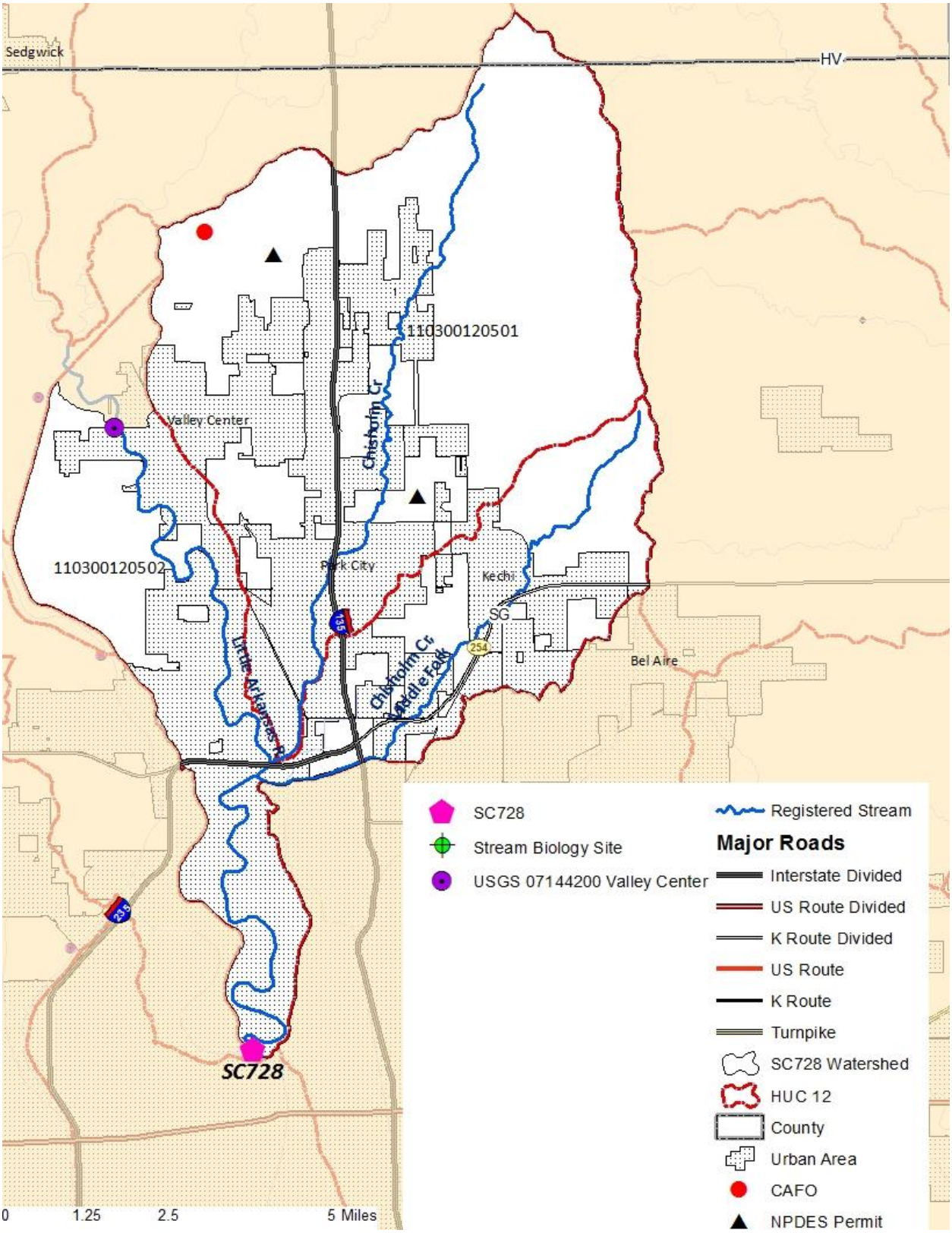


Figure 2. Map of contributing area for KDHE stream chemistry station SC729, Arkansas River at Wichita.

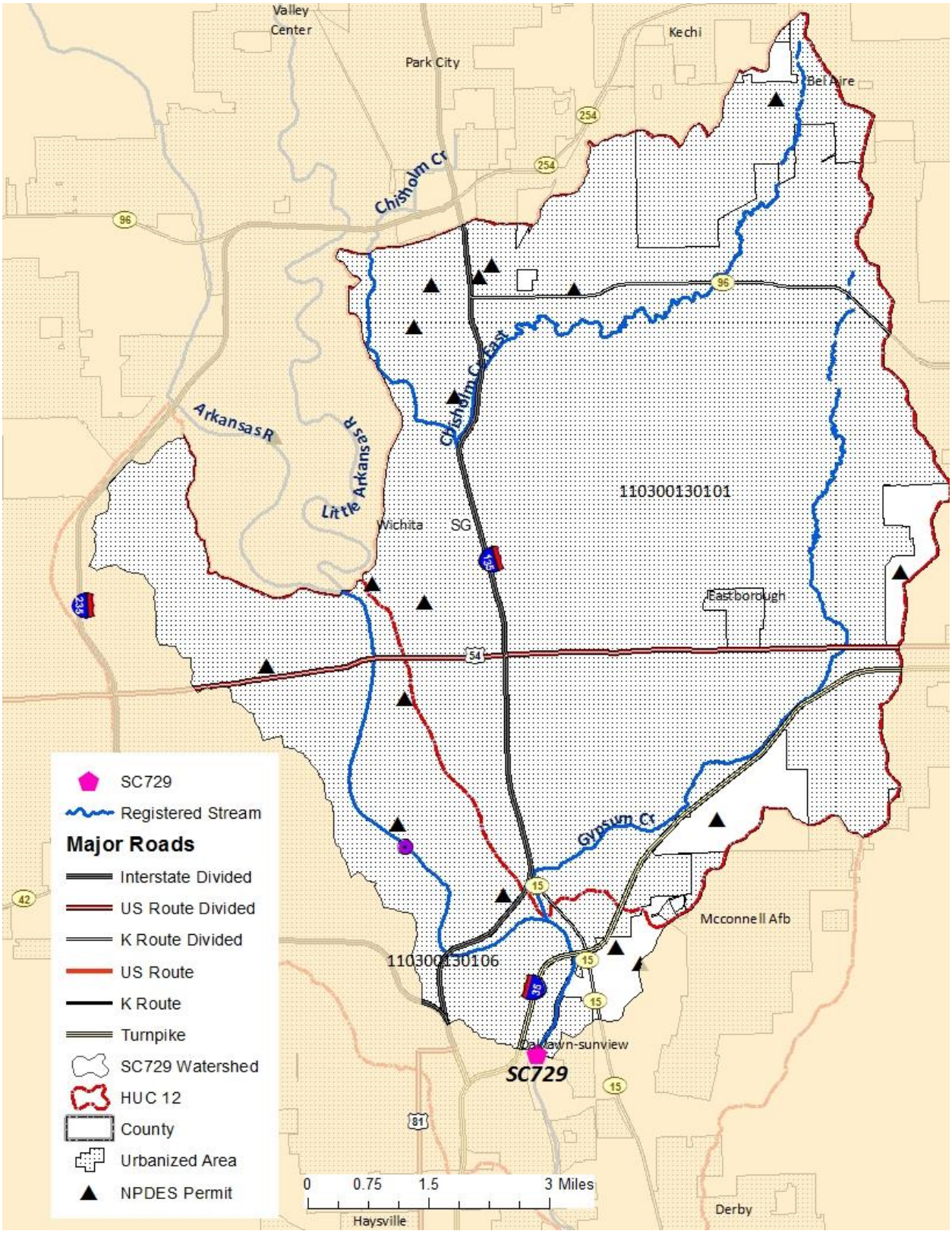


Figure 3. Map of contributing area for KDHE stream chemistry station SC281, Arkansas River at Derby.

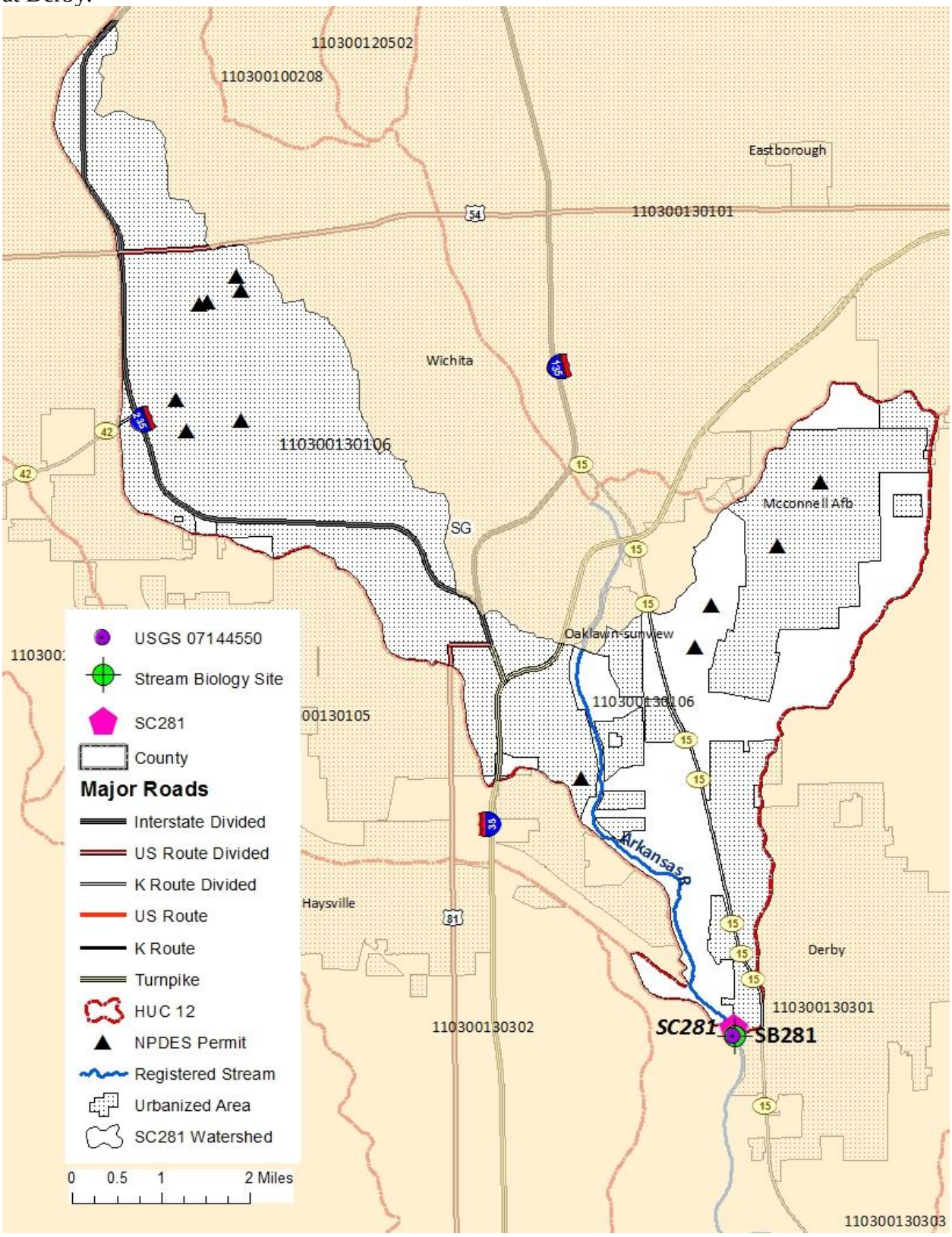


Figure 4. Map of contributing area for KDHE stream chemistry station SC527, Arkansas River at Oxford.

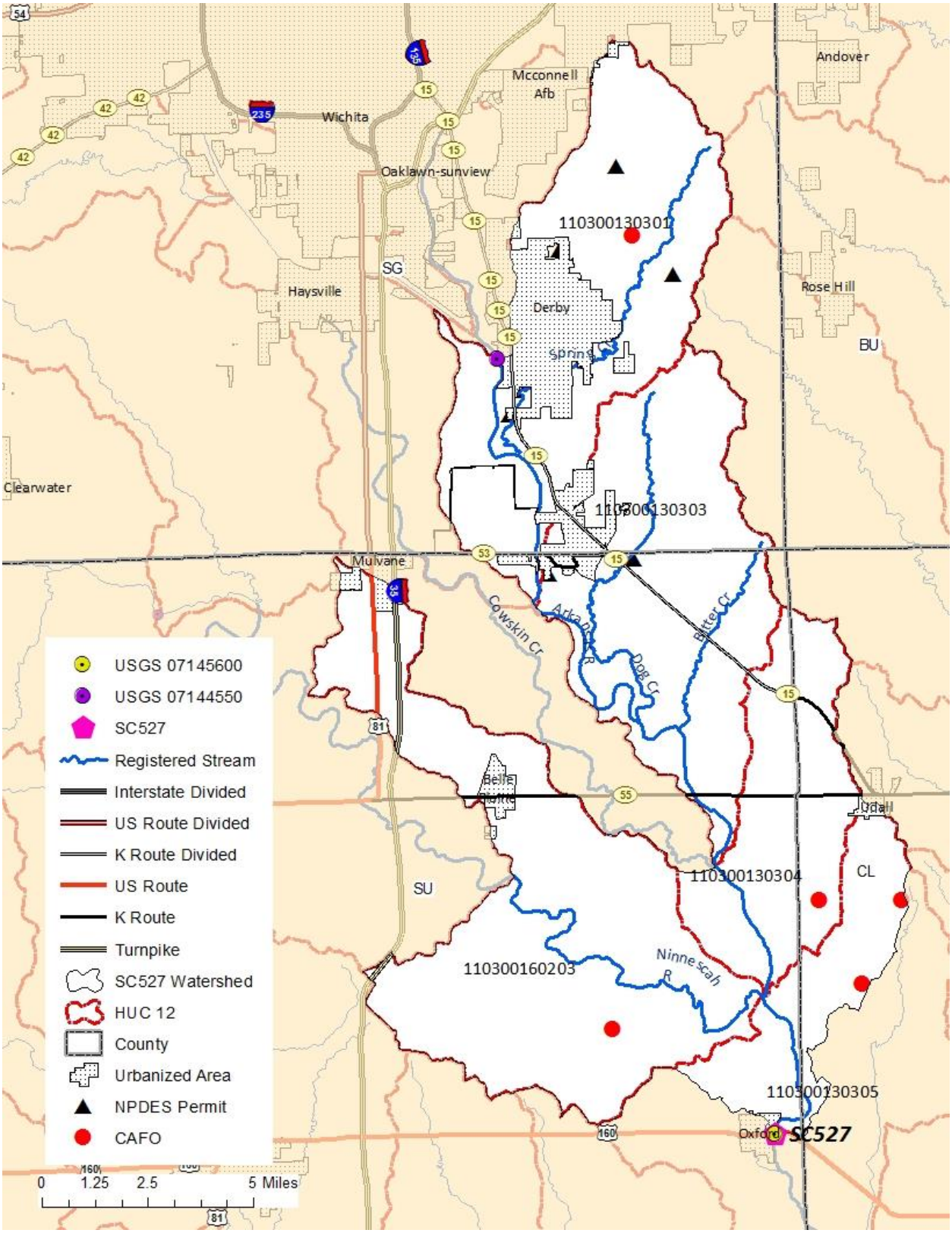
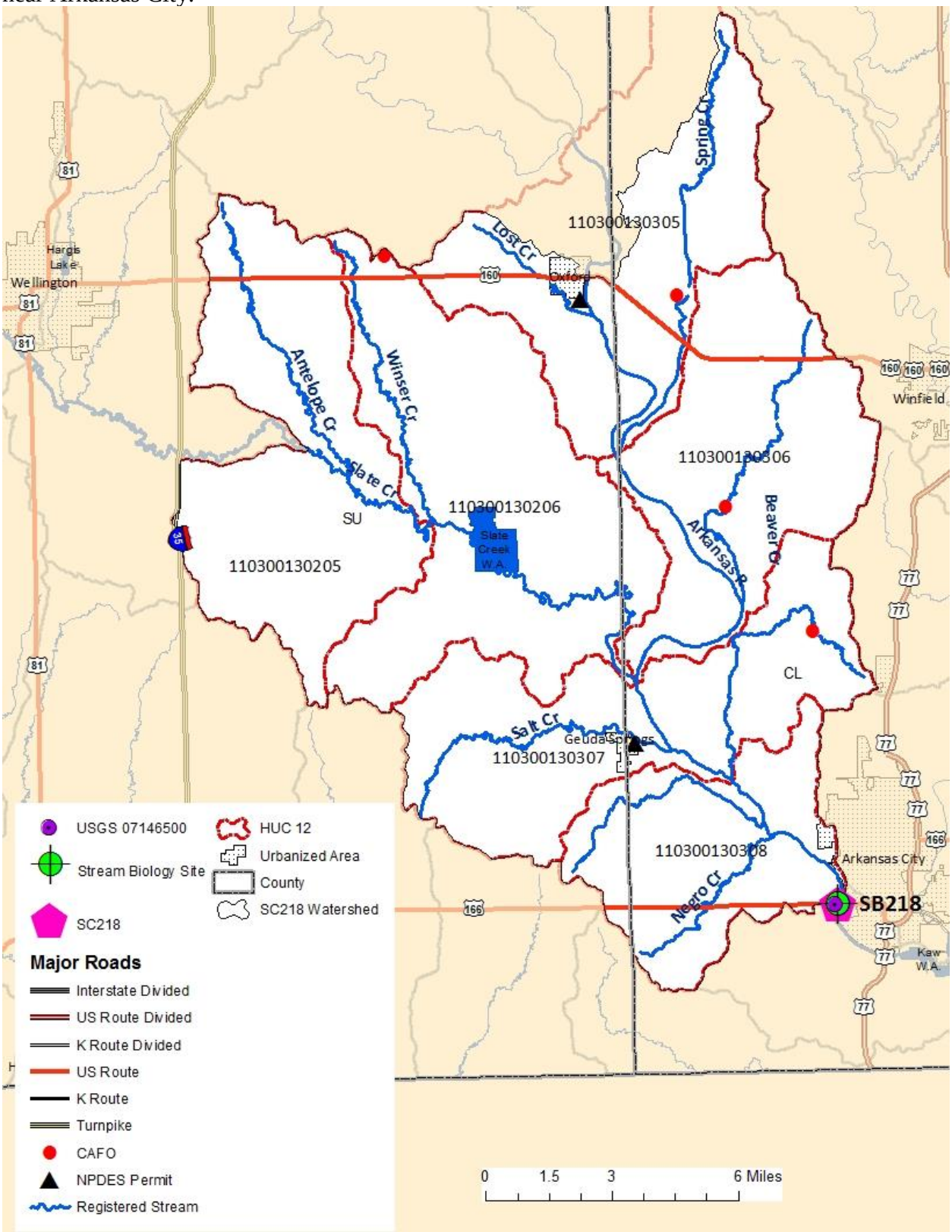


Figure 5. Map of contributing area for KDHE stream chemistry station SC218, Arkansas River near Arkansas City.



Impaired Use: Aquatic Life, Contact Recreation, and Domestic Water Supply (Kansas Department of Health and Environment, 2015).

Water Quality Criteria:
Nutrients – Narratives: The introduction of plant nutrients into streams, lakes, or wetlands from artificial sources shall be controlled to prevent the accelerated succession or replacement of aquatic biota or the projection of undesirable quantities or kinds of aquatic life (K.A.R. 28-16-28e(d)(2)(A)).

The introduction of plant nutrients into surface waters designated for domestic water supply use shall be controlled to prevent interference with the production of drinking water (K.A.R. 28-16-28e(d)(3)(D)).

The introduction of plant nutrients into surface waters designated for primary or secondary contact recreational use shall be controlled to prevent the development of objectionable concentrations of algae or algal by-products or nuisance growths of submersed, floating, or emergent aquatic vegetation (K.A.R. 28-26-28e(d)(7)(A)).

Taste-producing and odor-producing substances of artificial origin shall not occur in surface waters at concentrations that interfere with the production of potable water by conventional water treatment processes, that impart an unpalatable flavor to edible aquatic or semiaquatic life or terrestrial wildlife, or that result in noticeable odors in the vicinity of surface waters (K.A.R. 28-16-29e(b)(7)).

Dissolved Oxygen – Numeric: The concentration of dissolved oxygen in surface waters shall not be lowered by the influence of artificial sources of pollution. The Dissolved Oxygen criterion is 5.0 mg/L (K.A.R. 28-16-28e Tables of Numeric Criteria).

pH – Numeric: Artificial sources of pollution shall not cause the pH of any surface water outside of a zone of initial dilution to be below 6.5 and above 8.5 (K.A.R. 28-16-28e Tables of Numeric Criteria)

2. CURRENT WATER QUALITY CONDITIONS AND DESIRED ENDPOINT

Level of Support for Designated Uses, 2018 (303)d List: Phosphorus levels in the Little Arkansas River (SC728) and in the Arkansas River from Wichita (SC729) to Arkansas City (SC218) are consistently high. Excessive nutrients are not being controlled and are thus impairing aquatic life, domestic water supply, and contact recreation. The ultimate endpoint of this Total Maximum Daily Load (TMDL) will be to achieve the Kansas Surface Water Quality Standards by eliminating excessive primary productivity and impairment to aquatic life, domestic water supply, and recreation associated with excessive phosphorus. Additionally, this document will establish a TMDL for pH at the Arkansas River at Oxford (SC527) and Arkansas City (SC218).

Station Location and Period of Record:

Stream Chemistry (SC) Monitoring Station:

SC728: Active, permanent station at Little Arkansas River at Wichita, located on West Central Avenue Bridge in Wichita. Period of record: June 20, 2000 to April 18, 2017.

SC729: Active, permanent station at Arkansas River at Wichita, located on East 47th Street South Bridge in Wichita. Period of record: June 20, 2000 to April 24, 2017.

SC281: Active, permanent station at Arkansas River at Derby, located on County Road Bridge at the west edge of Derby. Period of record: March 20, 1990 to April 24, 2017.

SC527: Active, permanent station at Arkansas River at Oxford, located on Highway K-160 Bridge on the east edge of Oxford. Period of record: March 20, 1990 to April 24, 2017.

SC218: Active, permanent station at Arkansas River near Arkansas City, located on Highway U.S.-166 Bridge 0.5 mile west of Arkansas City. Period of record: March 20, 1990 to April 24, 2017.

Stream Biology (SB) Monitoring Station:

SB728: Active station at Little Arkansas River at Wichita, located on West Central Avenue Bridge in Wichita. Period of record: July 2, 2013 to October 12, 2016.

SB281: Active station at Arkansas River at Derby, located on County Road Bridge at the west edge of Derby. Period of record: May 3, 1990 to October 20, 2016.

SB218: Active station at Arkansas River near Arkansas City, located on Highway U.S.-166 Bridge 0.5 mile west of Arkansas City. Period of record: May 2, 1990 to October 19, 2016.

Streamflow Gage:

U.S. Geological Survey 07144200: Little Arkansas River at Valley Center. Period of record: January 1, 1990 to June 30, 2017. Located near Little Arkansas River at Wichita (SC728 and SB728).

U.S. Geological Survey 07144300: Arkansas River at Wichita. Period of record: January 1, 1990 to June 30, 2017. Located near Arkansas River at Wichita (SC729).

U.S. Geological Survey 07144550: Arkansas River at Derby. Period of record: January 1, 1990 to June 30, 2017. Located at Derby (SC281 and SB281).

U.S. Geological Survey 07145600: Arkansas River at Oxford. Period of record: gage height data was converted to streamflow May 10, 2012 to August 23, 2012; October 1, 2013 to March 2, 2014; and March 4, 2014 to April 16, 2014; streamflow data was available from April 17, 2014 to June 30, 2017. Located at Oxford (SC527).

U.S. Geological Survey 07146500: Arkansas River at Arkansas City. Period of record: January 1, 1990 to June 30, 2017. Located near Arkansas City (SC218 and SB218).

Hydrology: Flow conditions for this TMDL were analyzed using U.S. Geological Survey (USGS) streamgage data from the Little Arkansas River at Valley Center (07144200) and from the Arkansas River at Wichita (07144300), Derby (07144550), Oxford (07145600), and Arkansas City (07146500). All gages except Oxford have streamflow data available for the period of record January 1, 1990 to June 30, 2017. The gage at Oxford has streamflow data available for the period of record April 17, 2014 to June 30, 2017; available USGS gage height data was converted to streamflow data and applied to the following periods: May 10, 2012 to August 23, 2012; October 1, 2013 to March 2, 2014; and March 4, 2014 to April 16, 2014; a

regression model was developed using USGS long term estimated flows between Oxford (Sumner County, Site 4941; Perry et. al, 2004) and Arkansas City (Cowley County, Site 5268; Perry et. al, 2004) and applied to the following periods of record: January 1, 1990 to May 9, 2012; August 24, 2012 to September 30, 2013; and May 3, 2014.

Flow duration curves for the Little Arkansas River at Valley Center and the Arkansas River at Wichita, Derby, Oxford, and Arkansas City indicate increasing flow from the upstream (Wichita) to downstream (Arkansas City) sites during all flow conditions (**Figure 6**). There is approximately an order of magnitude difference in flow between the Little Arkansas River tributary and the main stem Arkansas River during all except the highest of flow conditions. Flow conditions for Kansas Department of Health and Environment (KDHE) stream chemistry (SC) stations were calculated using USGS streamgages and a watershed area ratio, where necessary (**Table 2**). The KDHE SC station ratios were based upon the following USGS streamgages: Little Arkansas River at Wichita (SC728) utilized streamflow from Little Arkansas River at Valley Center (07144200) and Arkansas River at Wichita (SC729) utilized streamflow from Arkansas River at Wichita (07144300). The SC stations located at Arkansas River at Derby (SC281), Oxford (SC527), and Arkansas City (SC218) utilized streamflow from USGS gages located at Derby (07144550), Oxford (07145600), and Arkansas City (07146500), respectively.

Figure 6. Flow duration curve for U.S. Geological Survey gaged sites located in the Little Arkansas and Arkansas River, January 1, 1990 to June 30, 2017.

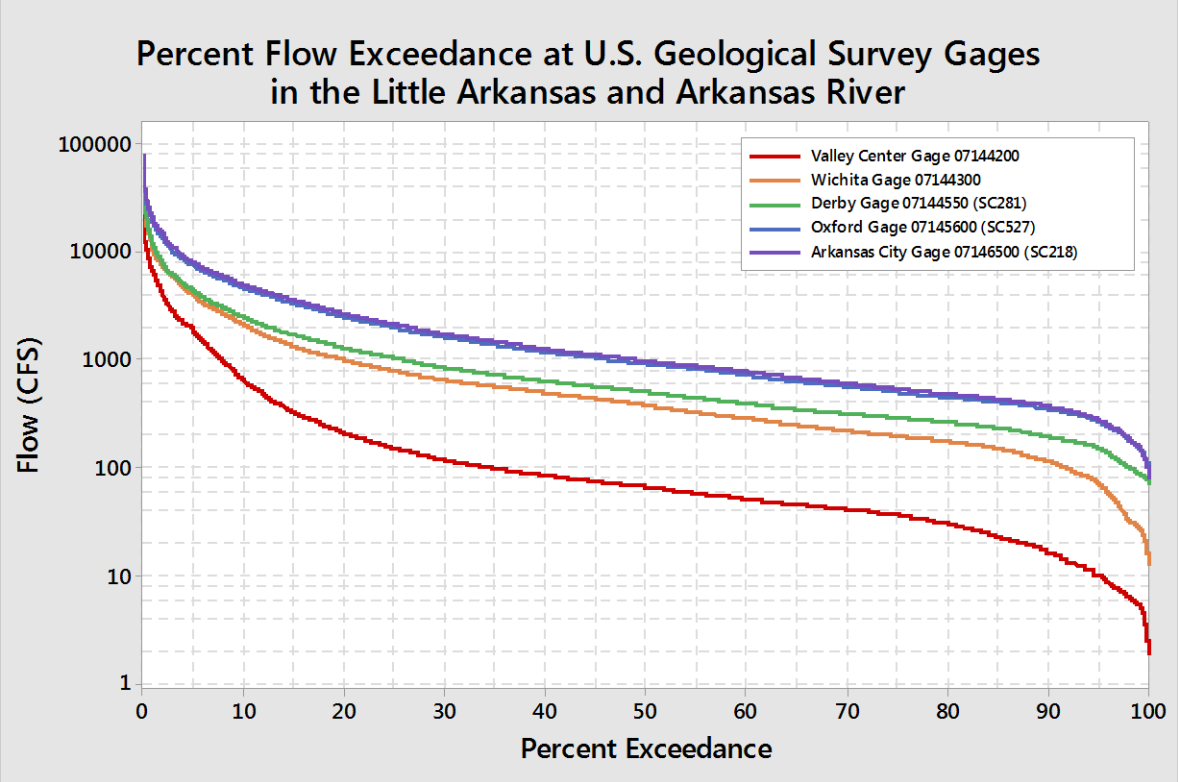


Table 2. Flow conditions and drainage area at U.S. Geological Survey gages and Kansas Department of Health and Environment stream chemistry (SC) stations in the Little Arkansas and Arkansas River, January 1, 1990 to June 30, 2017.

Stream	Station	Contributing Drainage Area (mi^2)	Mean Flow (CFS)	Percent of Flow Exceedance (CFS)				
				90%	75%	50%	25%	10%
Little Arkansas R at Valley Center	07144200	1,250	373	16	36	65	150	638
Little Arkansas R at Wichita	SC728	1,400	418	18	40	73	168	712
Arkansas R at Wichita	07144300	33,227	986	113	193	373	777	2,120
Arkansas R at Wichita	SC729	33,283	988	113	193	374	778	2,124
Arkansas R at Derby	07144550/SC281	33,567	1,177	189	285	498	1,030	2,490
Arkansas R at Oxford	07145600/SC527	35,474	2,071	347	495	911	1,971	4,645
Arkansas R near Arkansas City	07146500/SC218	36,106	2,219	367	528	967	2,110	4,980

Long term estimated flows for the Little Arkansas River, Arkansas River, and their tributaries can be found in **Table 3** (Perry et. al, 2004). The main tributaries to the Little Arkansas River are Chisholm Creek and Chisholm Creek, Middle Fork. The main tributaries to the Arkansas River are: Little Arkansas River and Chisholm Creek, which enter the Arkansas River above Wichita (SC729); Wichita-Valley Center (WVC) Floodway, which enters the Arkansas River above Derby (SC281); Cowskin Creek and Ninnescah River, which enter the Arkansas River above Oxford (SC527); and Slate Creek, which enters the Arkansas River above Arkansas City (SC218).

Table 3. U.S. Geological Survey (USGS) long term estimated flows for the Little Arkansas River, Arkansas River, and their tributaries (Perry et.al, 2004). Description: SG - Sedgwick; WVC - Wichita-Valley Center; SU - Sumner; CL – Cowley.

Stream	USGS Site	KSWR CUSEGA Number	County	Drainage Area (mi^2)	Mean Flow (CFS)	Flow Exceedance (%)					2-year Peak (CFS)
						90%	75%	50%	25%	10%	
Chisholm Cr	4071	110300121693	SG	32	13	0	0.2	2	5	15	1,590
Chisholm Cr, Middle Fork	4076	11030012817	SG	21	8	0	0	1	3	8	1,320
Little Arkansas R	**4165**	**110300121**	**SG**	**1,404**	**332**	**22**	**35**	**67**	**143**	**529**	**6,400**
Arkansas R	**4166**	**110300139**	**SG**	**36,500**	**348**	**93**	**124**	**159**	**289**	**647**	**7,380**
Chisholm Cr, East	4123	110300137	SG	17	6	0	0	1	2	6	1,140
Gypsum Cr	4278	110300135	SG	30	11	0	0.1	1	4	12	1,600
Chisholm Cr	4295	110300134	SG	61	22	0.1	2	5	12	29	1,650
Arkansas R	**4313**	**110300139**	**SG**	**37,913**	**1,046**	**126**	**226**	**433**	**858**	**2,220**	**9,740**
WVC Floodway	71	11030013456	SG	199	56	3	7	17	36	83	2,290
Arkansas R	**4495**	**110300133**	**SG**	**38,003**	**1,208**	**192**	**304**	**541**	**1,110**	**2,590**	**14,200**
Spring Cr	4494	1103001337	SG	29	11	0	0.2	2	5	13	1,620

Stream	USGS Site	KSWR CUSEGA Number	County	Drainage Area (mi^2)	Mean Flow (CFS)	Flow Exceedance (%)					2-year Peak (CFS)
						90%	75%	50%	25%	10%	
Dog Cr	4683	11030013531	SU	20	8	0	0.5	2	4	9	1,300
Bitter Cr	4689	1103001328	SU	18	6	0	0	0	1	5	1,240
Arkansas R	**4751**	**110300133**	**SU**	**38,086**	**1,232**	**197**	**311**	**554**	**1,135**	**2,641**	**14,380**
Cowskin Cr	4781	1103001310	SU	57	17	1	3	5	10	23	930
Ninnescah R	4859	110300161	SU	2,194	516	77	126	215	488	1,137	11,530
Arkansas R	**4941**	**110300132**	**SU**	**40,554**	**1,952**	**345**	**519**	**955**	**1,863**	**4,156**	**19,620**
Lost Cr	4942	1103001323	SU	9	2	0	0	0	0	1	790
Spring Cr	5044	1103001334	CL	28	9	0.4	1	2	4	10	1,590
Beaver Cr	5127	1103001333	CL	20	7	0	0.1	1	2	7	1,400
Arkansas R	**5128**	**110300132**	**CL**	**40,608**	**1,968**	**348**	**524**	**964**	**1,879**	**4,189**	**19,730**
Antelope Cr	5050	1103001325	SU	19	6	0	0	1	2	6	1,230
Winser Cr	5087	1103001332	SU	25	8	0	0	1	2	7	1,450
Slate Cr	5171	1103001317	SU	292	115	2	6	15	41	133	4,590
Salt Cr	5253	1103001322	CL	23	9	0	0	1	3	10	1,520
Spring Cr	5228	1103001321	CL	19	8	0.4	1	2	4	10	1,460
Spring Cr	5287	1103001319	CL	11	5	0	0	1	1	5	1,030
Negro Cr	5337	1103001320	CL	12	5	0	0	0.4	1	5	1,140
Arkansas R	**5354**	**110300131**	**CL**	**41,017**	**2,087**	**373**	**558**	**1,030**	**2,000**	**4,440**	**20,600**

Annual mean flows at all gages are higher than median flows, with mean and median high flows occurring in 1993 (**Figures 7-11**). The lowest annual mean flows were in 2006 at Valley Center, 1991 at Wichita and Derby, and 2011 at Oxford and Arkansas City. The wide range of annual low mean values may be influenced by urban and regional factors, as 1991 was the lowest streamflow for gages in/near Wichita and 2011 was the lowest streamflow for the downstream Oxford and Arkansas City gages. The lowest annual median flows were more consistent than lowest mean flows and occurred in 1991 at Oxford and in 2012 at Valley Center, Wichita, Derby, and Arkansas City. The highest annual total precipitation in the Wichita area occurred in 2008, with more than 50 inches of rainfall (**Figures 7-11**). Annual flows generally coincide with National Oceanic and Atmospheric Administration (NOAA) annual total precipitation from Wichita station USW00003928, though it does not tend to coincide with peak annual flows, possibly due to variability in rainfall intensity. Annual peak flows were highest in 1993 at Valley Center and Wichita (**Figures 12-13**) and 1998 at Derby, Oxford, and Arkansas City (**Figures 14-16**).

Figure 7. Annual mean and median flows for U.S. Geological Survey gage 07144200 at Valley Center located near Wichita (SC728) in the Little Arkansas River, January 1, 1990 to June 30, 2017, and annual total precipitation at NOAA station USW00003928 in Wichita, January 1, 1990 to December 31, 2016.

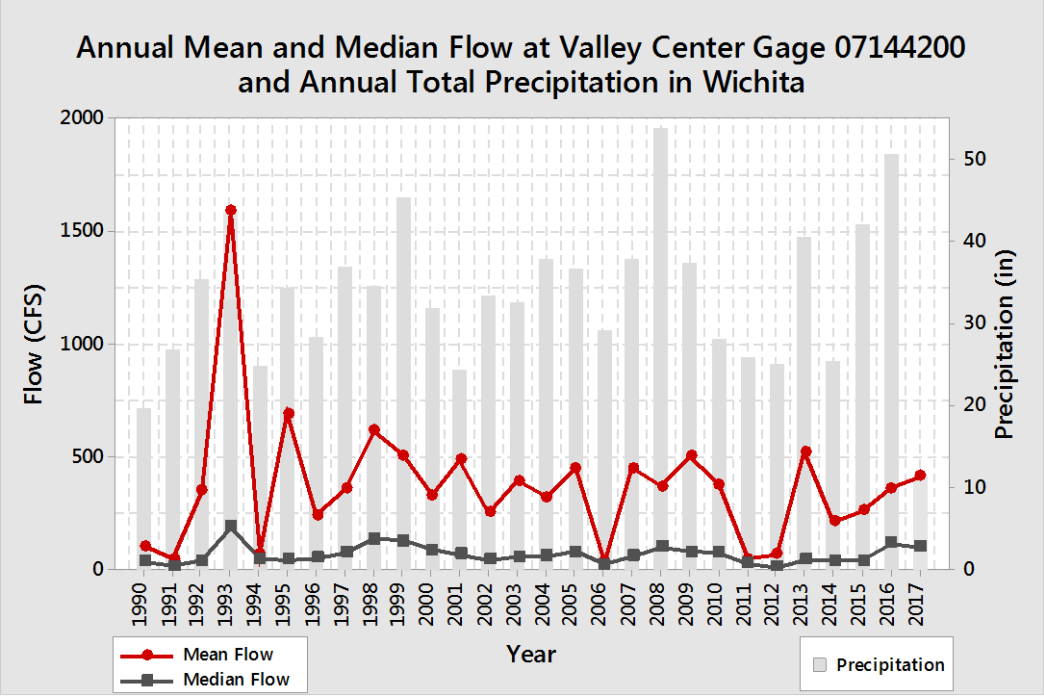


Figure 8. Annual mean and median flows for U.S. Geological Survey gage 07144300 at Wichita located near Wichita (SC729) in the Arkansas River, January 1, 1990 to June 30, 2017, and annual total precipitation at NOAA station USW00003928 in Wichita, January 1, 1990 to December 31, 2016.

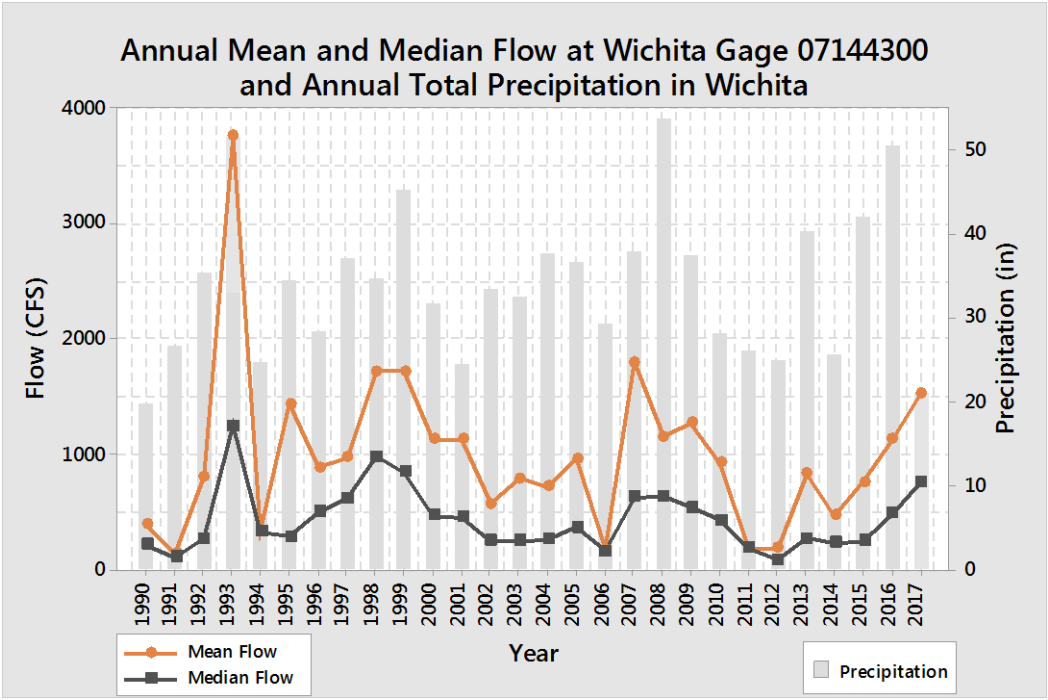


Figure 9. Annual mean and median flows for U.S. Geological Survey gage 07144550 at Derby located at Derby (SC281) in the Arkansas River, January 1, 1990 to June 30, 2017, and annual total precipitation at NOAA station USW00003928 in Wichita, January 1, 1990 to December 31, 2016.

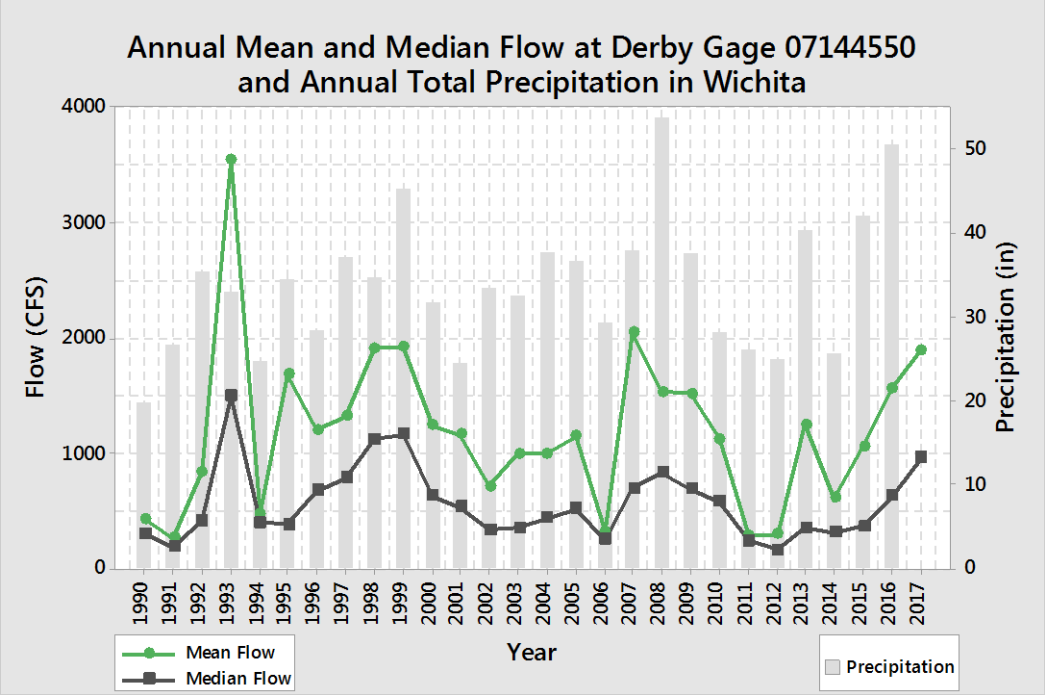


Figure 10. Annual mean and median flows for U.S. Geological Survey gage 07145600 at Oxford located at Oxford (SC527) in the Arkansas River, January 1, 1990 to June 30, 2017, and annual total precipitation at NOAA station USW00003928 in Wichita, January 1, 1990 to December 31, 2016.

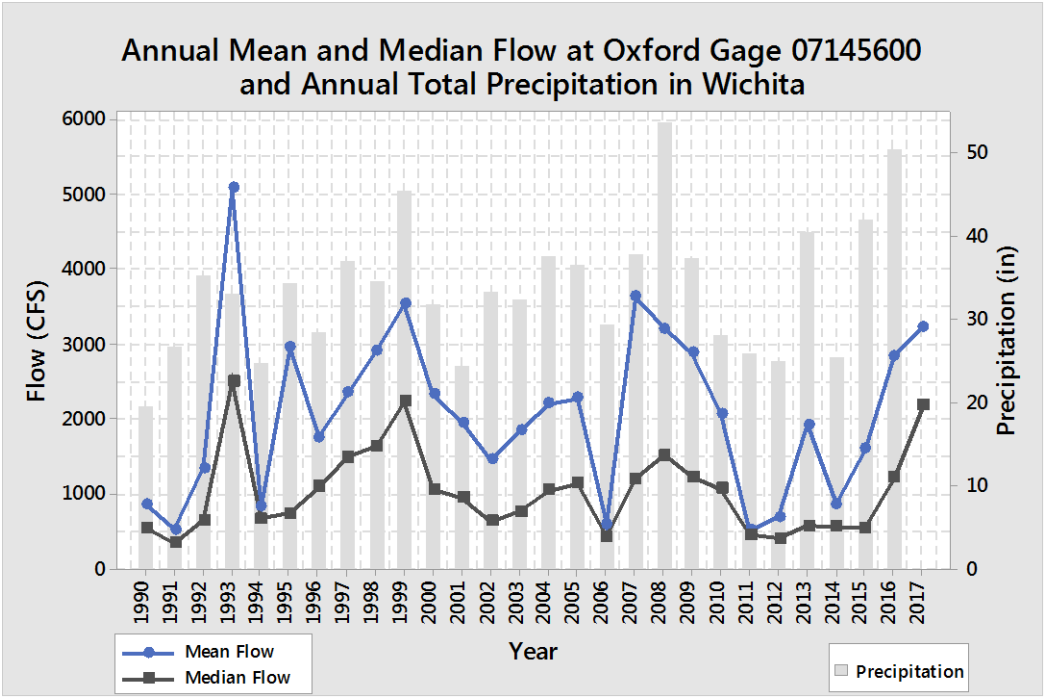


Figure 11. Annual mean and median flows for U.S. Geological Survey gage 07146500 at Arkansas City located at Arkansas City (SC218) in the Arkansas River, January 1, 1990 to June 30, 2017, and annual total precipitation at NOAA station USW00003928 in Wichita, January 1, 1990 to December 31, 2016.

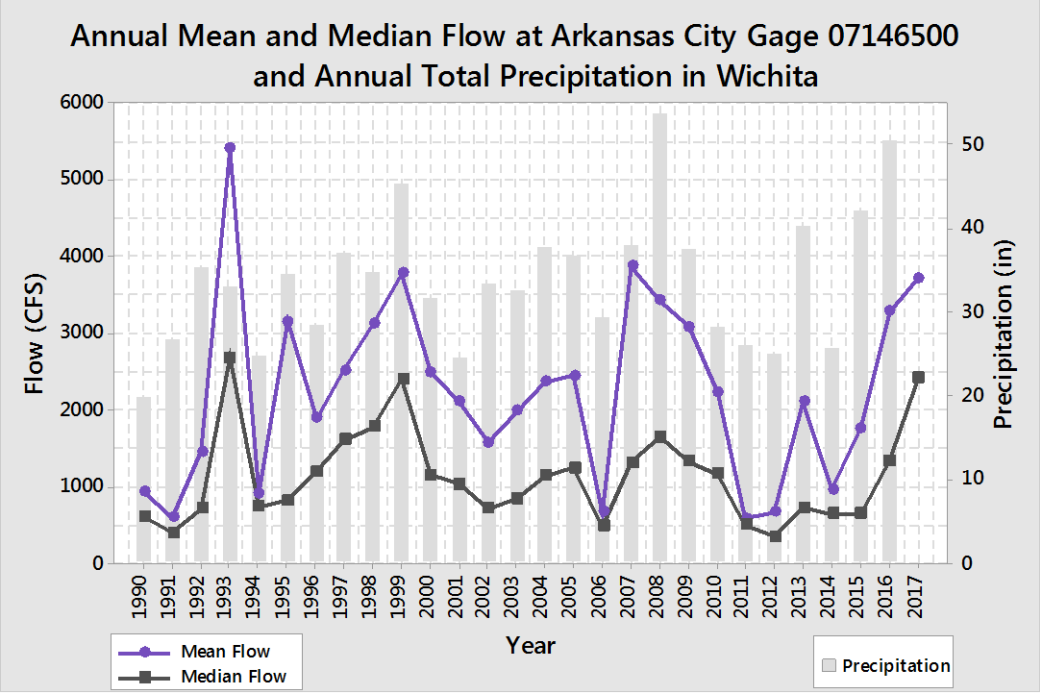


Figure 12. Annual peak flows for U.S. Geological Survey gage 07144200 at Valley Center located near Wichita (SC728) in the Little Arkansas River, January 1, 1990 to June 30, 2017.

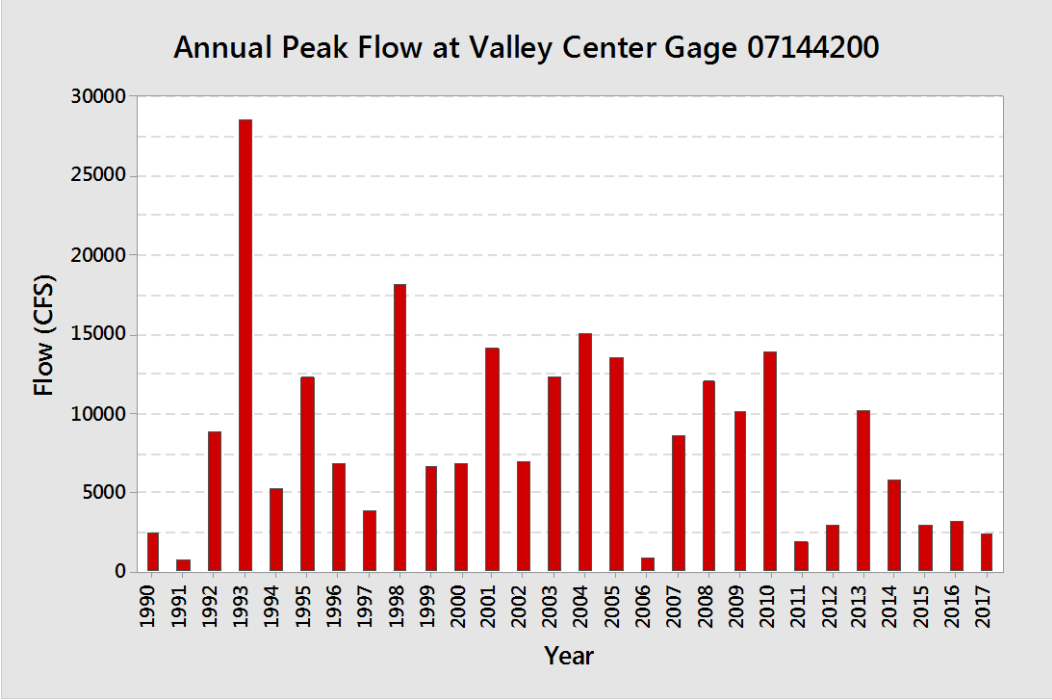


Figure 13. Annual peak flows for U.S. Geological Survey gage 07144300 at Wichita located near Wichita (SC729) in the Arkansas River, January 1, 1990 to June 30, 2017.

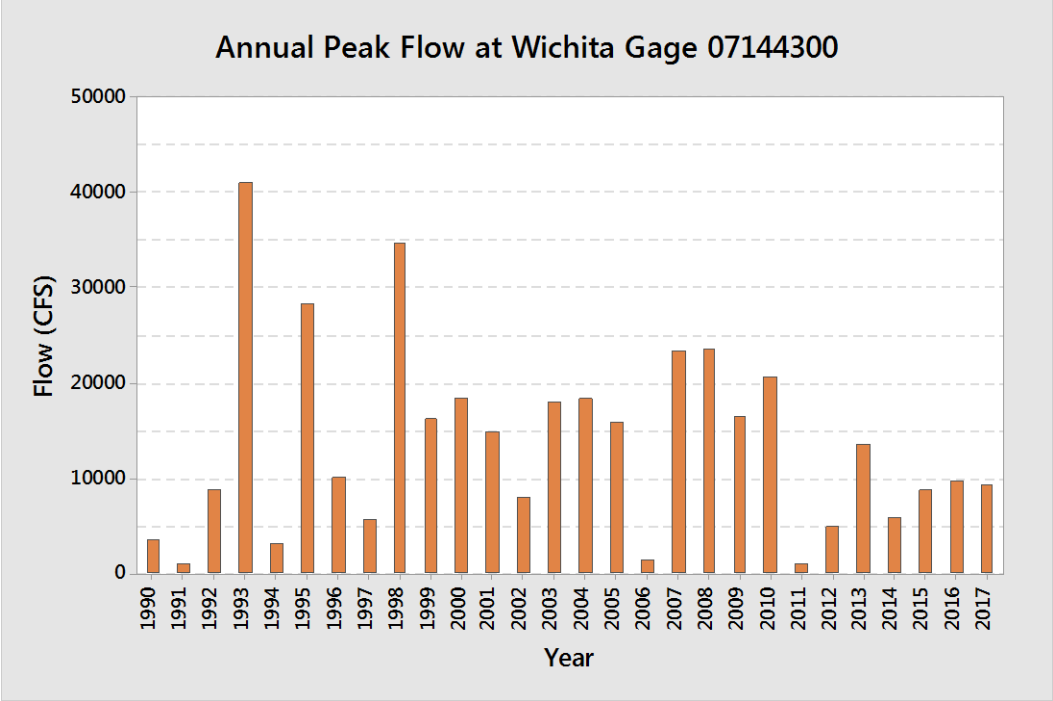


Figure 14. Annual peak flows for U.S. Geological Survey gage 07144550 at Derby located at Derby (SC281) in the Arkansas River, January 1, 1990 to June 30, 2017.

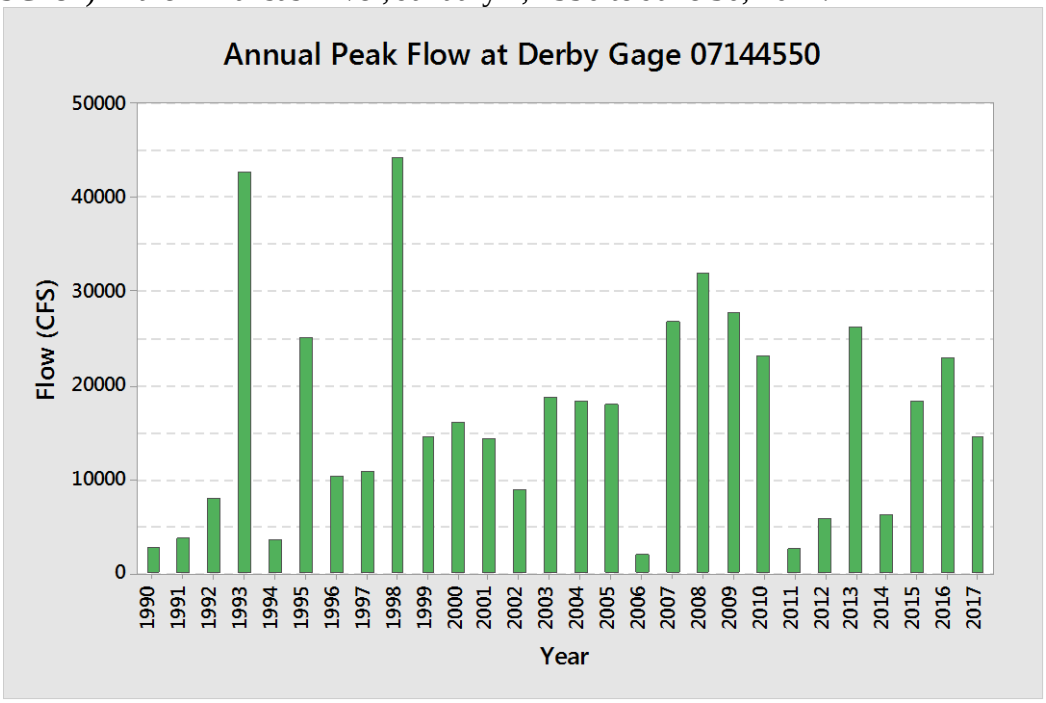


Figure 15. Annual peak flows for U.S. Geological Survey gage 07145600 at Oxford located at Oxford (SC527) in the Arkansas River, January 1, 1990 to June 30, 2017.

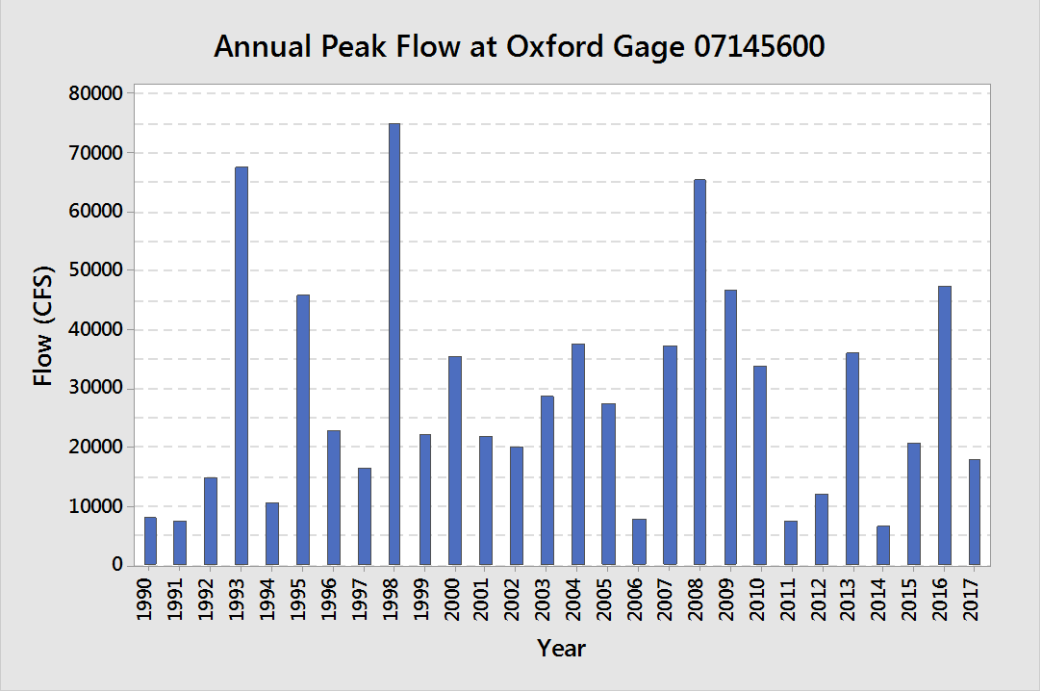
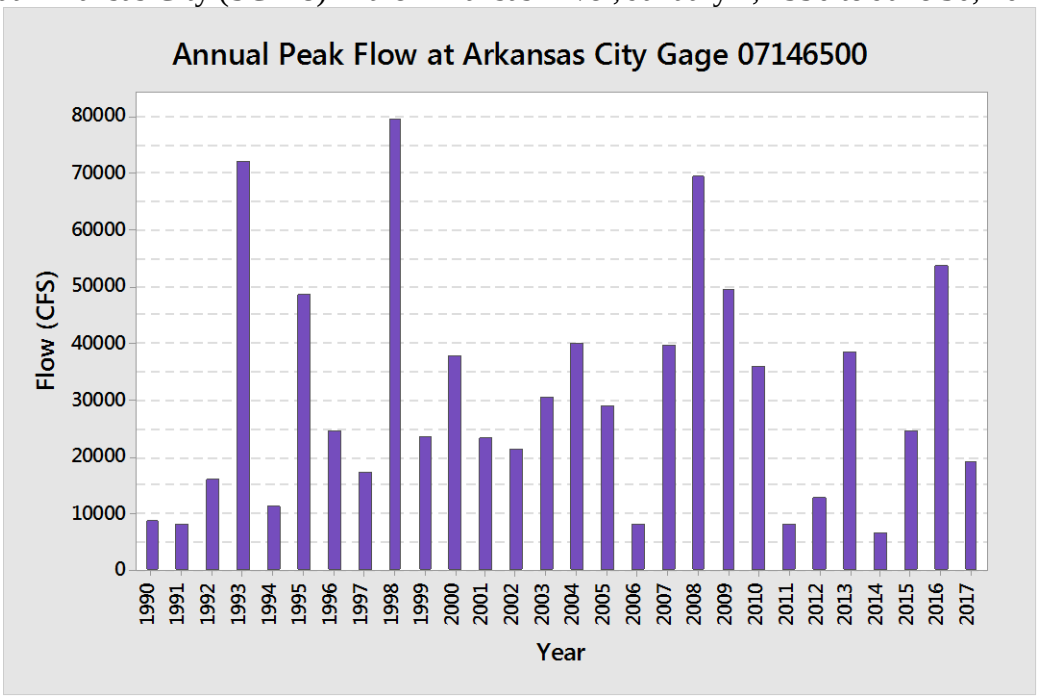


Figure 16. Annual peak flows for U.S. Geological Survey gage 07146500 at Arkansas City located at Arkansas City (SC218) in the Arkansas River, January 1, 1990 to June 30, 2017.

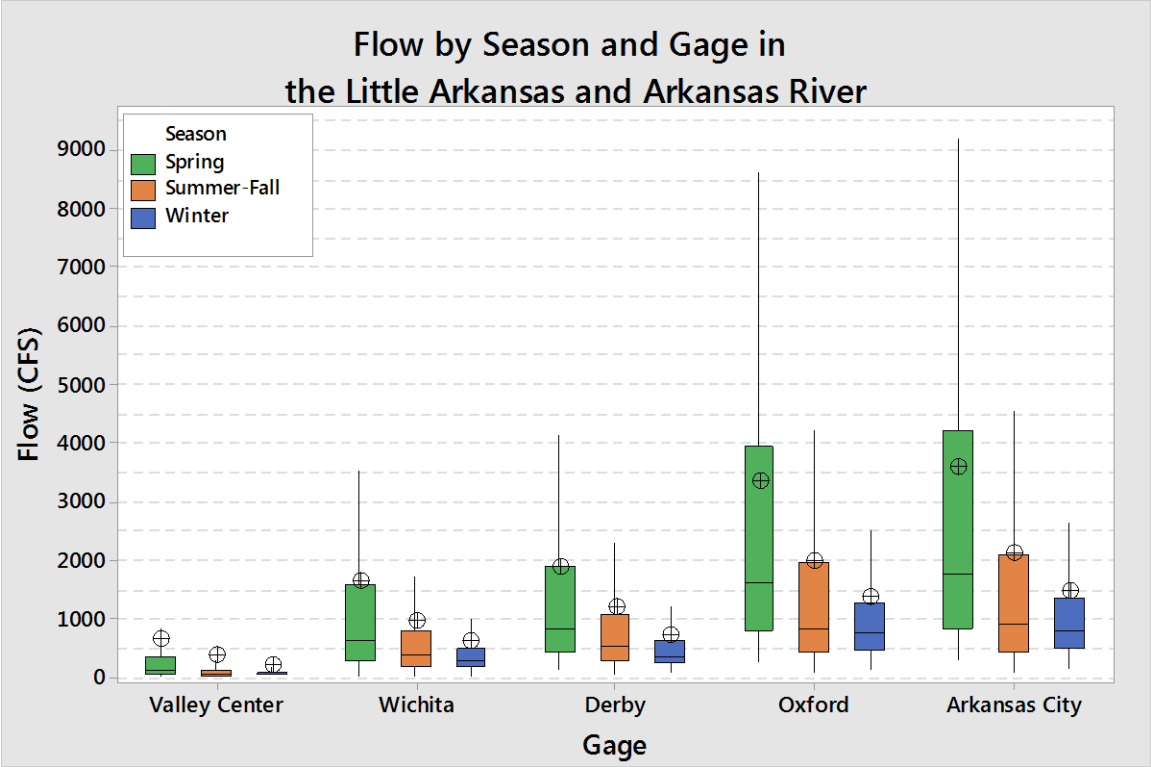


Seasonally, high flows occur in spring (April through June) and low flows occur in winter (November through March; **Table 4**; **Figure 17**). Accordingly, monthly mean and median flows at all gages are highest in May and June and are lowest in December and January. Across all seasons, flow increases as moves downstream.

Table 4. Flow means and medians by season (spring: April through June, summer-fall: July through October, winter: November through March) for U.S. Geological Survey gaged sites located in the Little Arkansas and Arkansas River, January 1, 1990 to June 30, 2017.

Site	Gage	Streamflow (CFS)							
		Spring		Summer-Fall		Winter		All Seasons	
		Mean	Median	Mean	Median	Mean	Median	Mean	Median
Little Arkansas R at Valley Center	07144200	647	125	362	51	216	55	373	65
Arkansas R at Wichita	07144300	1,626	640	970	402	609	283	986	373
Arkansas R at Derby	07144550	1,884	830	1,201	531	727	369	1,177	498
Arkansas R at Oxford	07145600	3,337	1,632	1,969	822	1,380	755	2,071	911
Arkansas R at Arkansas City	07146500	3,574	1,750	2,119	890	1,472	810	2,219	967

Figure 17. Flows by season for U.S. Geological Survey gaged sites located in the Little Arkansas and Arkansas River, January 1, 1990 to June 30, 2017.



Total Phosphorus: Overall, mean and median total phosphorus (TP) concentrations in the Arkansas River are highest at Derby (SC281), with a mean concentration of 0.678 mg/L and a median concentration of 0.588 mg/L (**Figure 18**; **Table 5**). Downstream of Derby (SC281), TP concentrations decline at Oxford (SC527), with mean and median concentrations of 0.519 and

0.442 mg/L, respectively; concentrations increase again near Arkansas City (SC218), with a mean of 0.555 mg/L and a median of 0.500 mg/L. Total phosphorus concentrations are lowest at the most upstream station, Arkansas River at Wichita (SC729), with a mean concentration of 0.317 mg/L and a median concentration of 0.203 mg/L. The station at the Little Arkansas River at Wichita (SC728), which is located above the Little Arkansas River's confluence with the Arkansas River, contributes TP concentrations which fall between the high and low mean and median ranges along the Arkansas River, with mean and median concentrations of 0.447 and 0.385 mg/L, respectively.

Figure 18. Total phosphorus by station in the Little Arkansas and Arkansas River, March 20, 1990 to April 24, 2017.

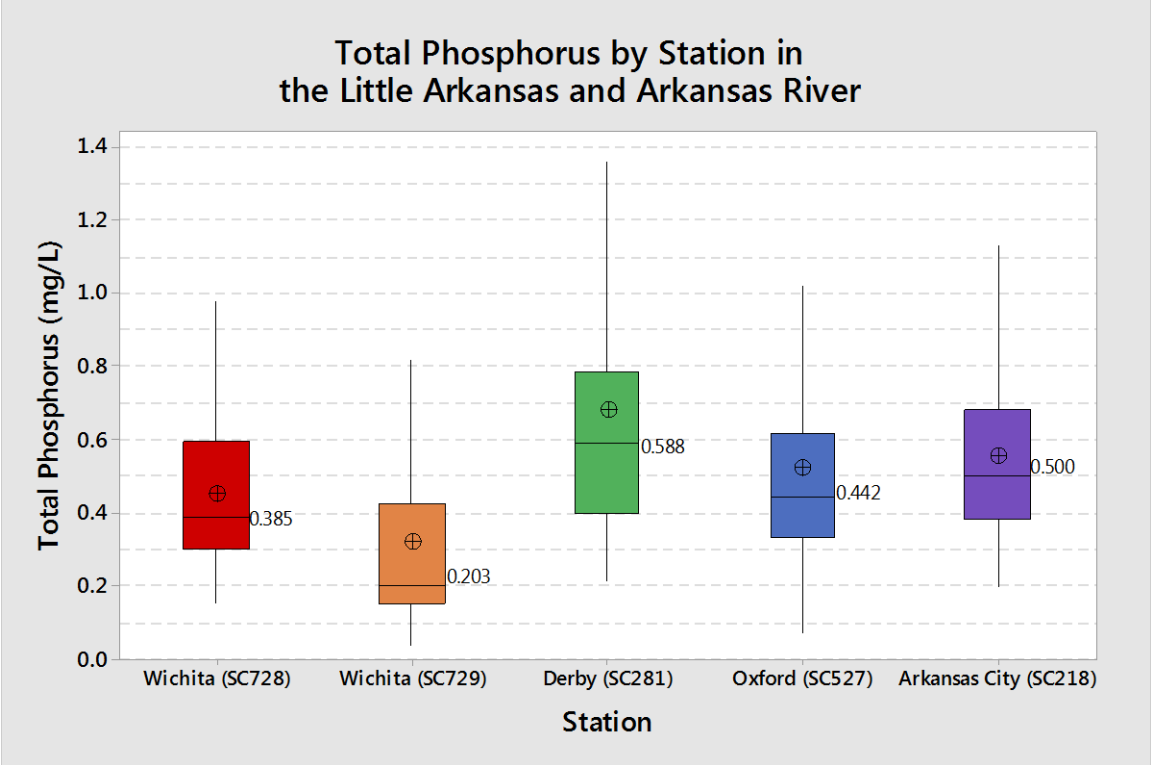


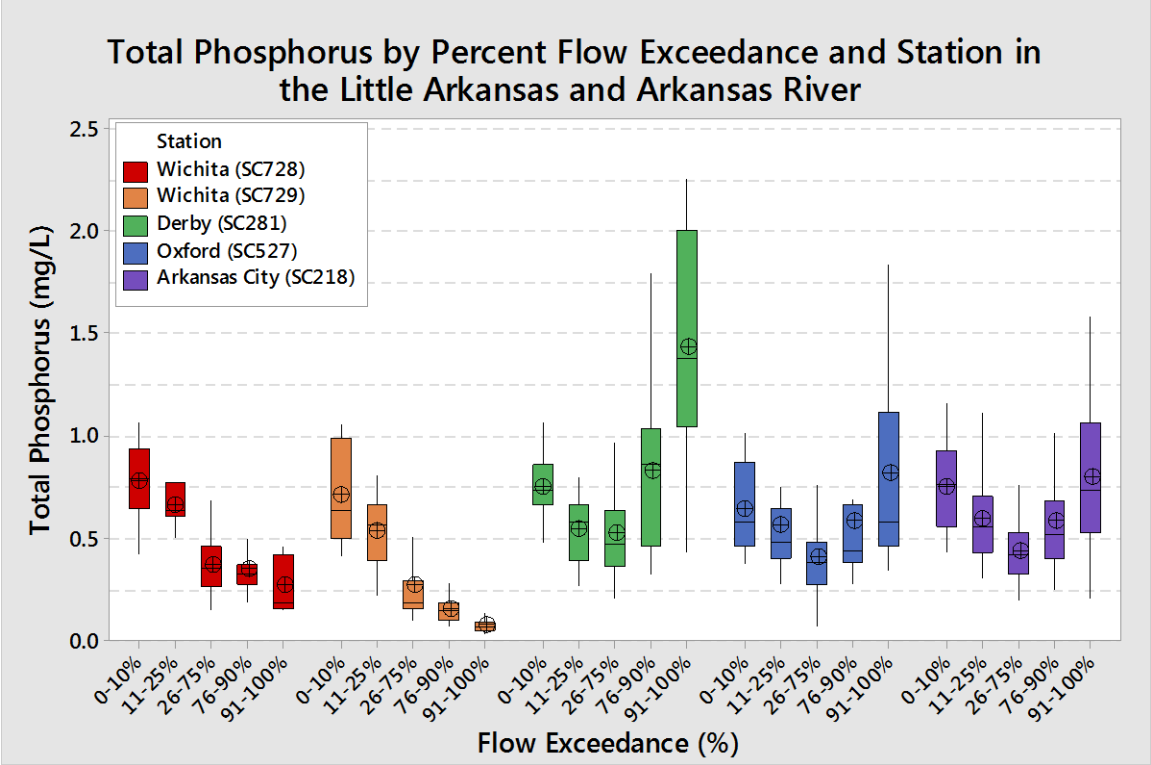
Table 5. Total phosphorus mean, median, and sample number (N) in the Little Arkansas and Arkansas River, March 20, 1990 to April 24, 2017.

Station	Stream	Mean	Median	N
SC728	Little Arkansas River at Wichita	0.447	0.385	82
SC729	Arkansas River at Wichita	0.317	0.203	84
SC281	Arkansas River at Derby	0.678	0.588	145
SC527	Arkansas River at Oxford	0.519	0.442	144
SC218	Arkansas River near Arkansas City	0.555	0.500	145

There is a distinct divide among TP concentrations by percent flow exceedance in the Arkansas River: SC stations above Derby (SC281) have higher TP concentrations during higher flow conditions (0-25%), and SC stations at or below Derby (SC281) have higher TP concentrations during lower flow conditions (76-100%; **Figure 19**).

The stations at Wichita (SC728 and SC729) both have their highest mean and median TP concentrations during higher flow conditions (**Figure 19**; **Table 6**), which is indicative of nonpoint sources and stormwater runoff. It is noteworthy that, while individual TP sample concentrations in the Arkansas River at Wichita (SC729) decrease steadily across the range of percent flow exceedances (**Figure 20**), concentrations in the Little Arkansas River at Wichita (SC728) become more variable during normal (26-75%) and below normal flow conditions (**Figure 21**), revealing the influence of municipal point sources at this station.

Figure 19. Total phosphorus by percent flow exceedance and station in the Little Arkansas and Arkansas River, March 20, 1990 to April 24, 2017.



The stations at Derby (SC281), Oxford (SC527), and Arkansas City (SC218) all have means and medians during lower flow conditions that are similar to or surpass those seen higher flow conditions (**Figure 19**; **Table 6**), which is indicative of point source effluent TP entering the stream. Further indications of point source influence on TP concentrations at these stations can be seen in the deviation of individual TP sample concentrations during normal flow conditions and the increase in TP concentrations during lower flow conditions (**Figures 22-24**).

Table 6. Mean, median, and sample size (N) for total phosphorus by percent flow exceedance, season (spring: April through June, summer-fall: July through October, winter: November through March), and station in the Little Arkansas and Arkansas River, March 20, 1990 to April 24, 2017. Values with no data are denoted with a – symbol.

Flow Exceedance (%)	Total Phosphorus (mg/L)											
	Spring			Summer-Fall			Winter			All Seasons		
	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median	N
Little Arkansas River at Wichita (SC728)												
0-10	0.761	0.764	6	0.813	0.813	2	0.782	0.818	4	0.777	0.797	12
11-25	0.639	0.642	3	0.672	0.630	3	0.676	0.676	1	0.659	0.642	7
26-75	0.484	0.490	9	0.444	0.453	12	0.292	0.306	22	0.375	0.360	43
76-90	0.430	0.437	4	0.378	0.310	5	0.278	0.266	6	0.352	0.327	15
91-100	–	–	–	0.305	0.289	4	0.149	0.149	1	0.274	0.189	5
0-100	**0.571**	**0.511**	**22**	**0.465**	**0.451**	**26**	**0.354**	**0.314**	**34**	**0.447**	**0.385**	**82**
Arkansas River at Wichita (SC729)												
0-10	0.685	0.574	6	0.663	0.663	1	0.779	0.860	3	0.711	0.640	10
11-25	0.580	0.590	3	0.515	0.547	6	0.544	0.544	1	0.538	0.567	10
26-75	0.310	0.306	8	0.307	0.253	13	0.231	0.160	21	0.270	0.194	42
76-90	0.187	0.156	5	0.155	0.161	3	0.127	0.110	7	0.153	0.155	15
91-100	–	–	–	0.089	0.079	4	0.060	0.054	3	0.077	0.071	7
0-100	**0.421**	**0.368**	**22**	**0.317**	**0.250**	**27**	**0.251**	**0.159**	**35**	**0.317**	**0.203**	**84**
Arkansas River at Derby (SC281)												
0-10	0.763	0.732	9	0.677	0.677	2	0.767	0.760	5	0.754	0.740	16
11-25	0.496	0.410	7	0.607	0.604	10	0.494	0.615	5	0.546	0.584	22
26-75	0.548	0.520	15	0.614	0.564	27	0.443	0.383	30	0.529	0.477	72
76-90	1.10	1.04	5	1.36	1.36	2	0.673	0.547	16	0.825	0.860	23
91-100	0.740	0.740	1	1.57	1.66	6	1.41	1.36	5	1.43	1.38	12
0-100	**0.670**	**0.630**	**37**	**0.769**	**0.640**	**47**	**0.613**	**0.462**	**61**	**0.678**	**0.588**	**145**
Arkansas River at Oxford (SC527)												
0-10	0.638	0.618	9	0.512	0.512	1	0.682	0.685	4	0.642	0.582	14
11-25	0.457	0.431	9	0.715	0.626	9	0.489	0.511	5	0.565	0.480	23
26-75	0.458	0.440	15	0.513	0.472	25	0.313	0.291	34	0.410	0.388	74
76-90	0.695	0.450	3	0.732	0.564	4	0.517	0.400	13	0.587	0.445	20
91-100	0.420	0.420	1	1.01	1.10	8	0.542	0.574	4	0.819	0.578	13
0-100	**0.520**	**0.450**	**37**	**0.655**	**0.530**	**47**	**0.412**	**0.366**	**60**	**0.519**	**0.442**	**144**
Arkansas River near Arkansas City (SC218)												
0-10	0.749	0.763	10	0.595	0.595	2	0.822	0.874	4	0.748	0.763	16
11-25	0.549	0.502	10	0.616	0.608	8	0.657	0.638	5	0.596	0.563	23
26-75	0.554	0.476	12	0.490	0.460	25	0.370	0.359	34	0.443	0.420	71
76-90	0.712	0.660	5	0.709	0.585	4	0.506	0.450	13	0.590	0.526	22
91-100	–	–	–	0.924	1.04	8	0.601	0.537	5	0.800	0.734	13
0-100	**0.627**	**0.591**	**37**	**0.608**	**0.550**	**47**	**0.471**	**0.428**	**61**	**0.555**	**0.500**	**145**

Figure 20. Total phosphorus by percent flow exceedance at Wichita (SC728) in the Little Arkansas River, June 20, 2000 to April 18, 2017.

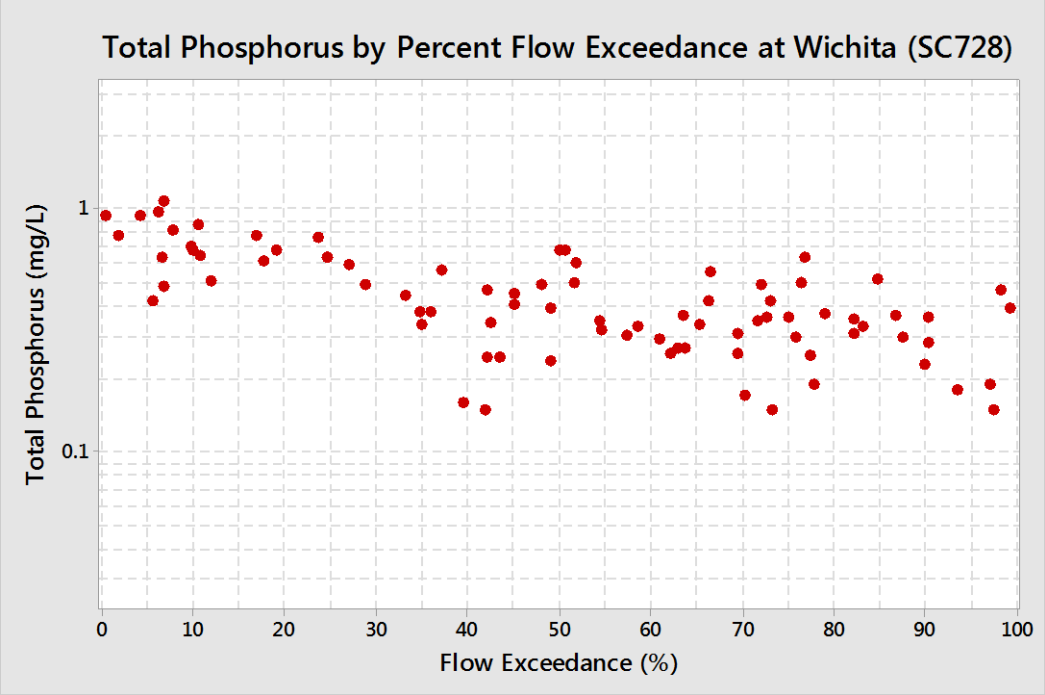


Figure 21. Total phosphorus by percent flow exceedance at Wichita (SC729) in the Arkansas River, June 20, 2000 to April 24, 2017.

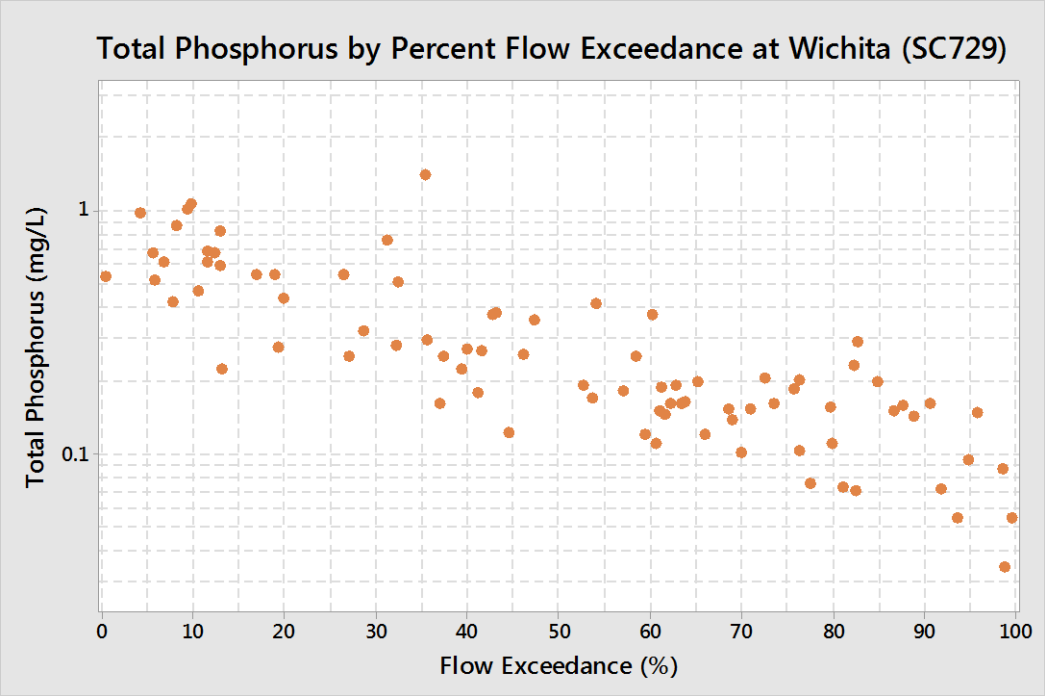


Figure 22. Total phosphorus by percent flow exceedance at Derby (SC281) in the Arkansas River, March 20, 1990 to April 24, 2017.

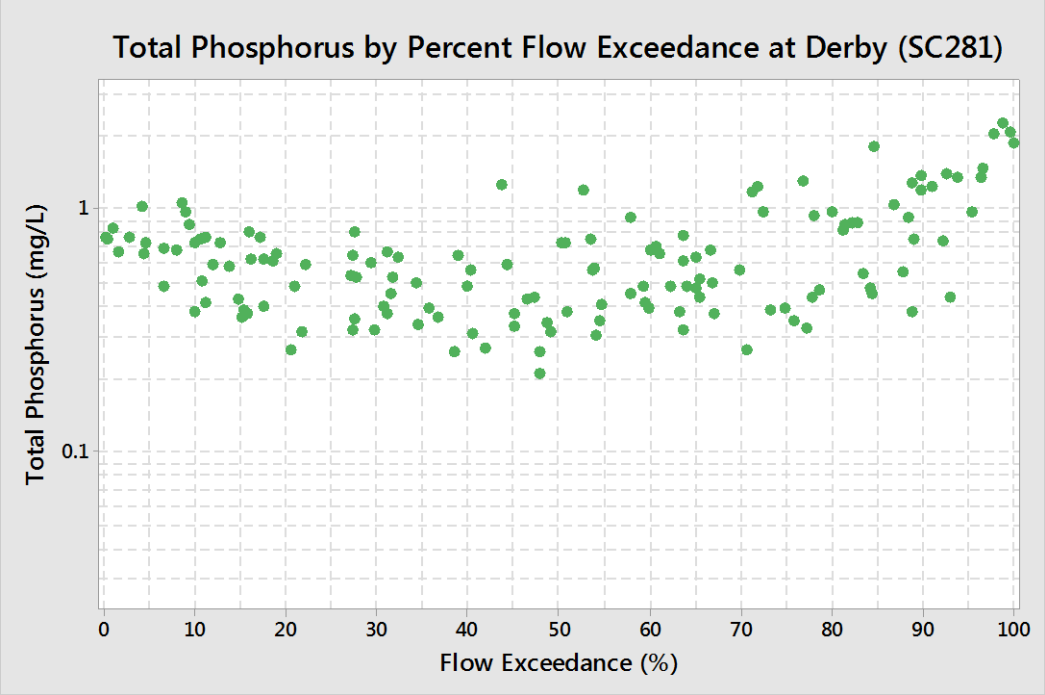


Figure 23. Total phosphorus by percent flow exceedance at Oxford (SC527) in the Arkansas River, March 20, 1990 to April 24, 2017.

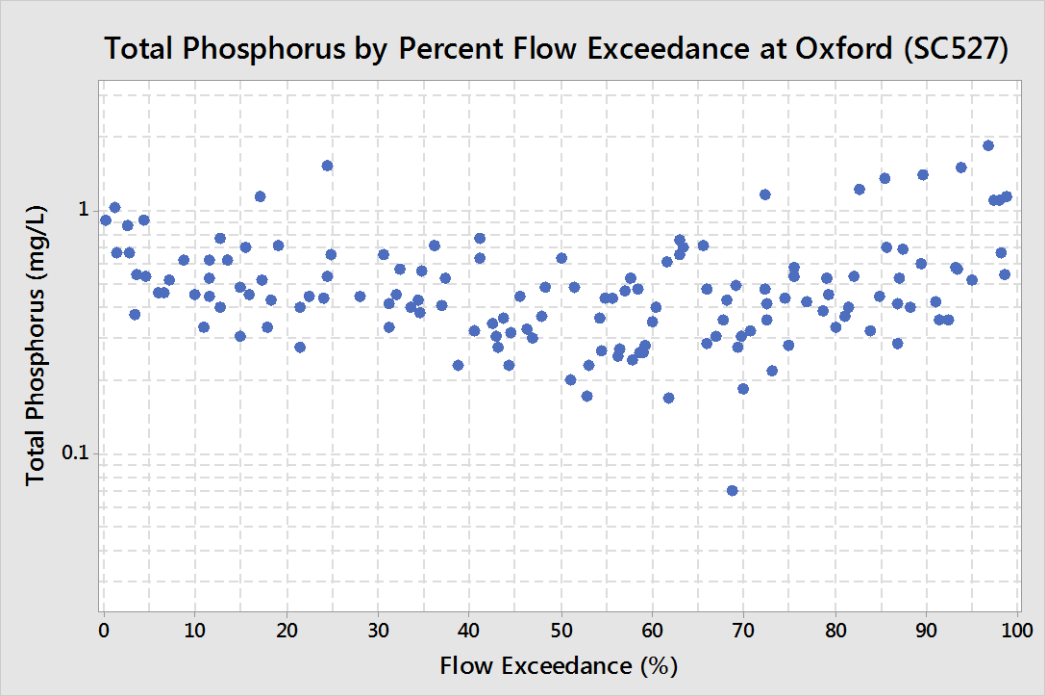
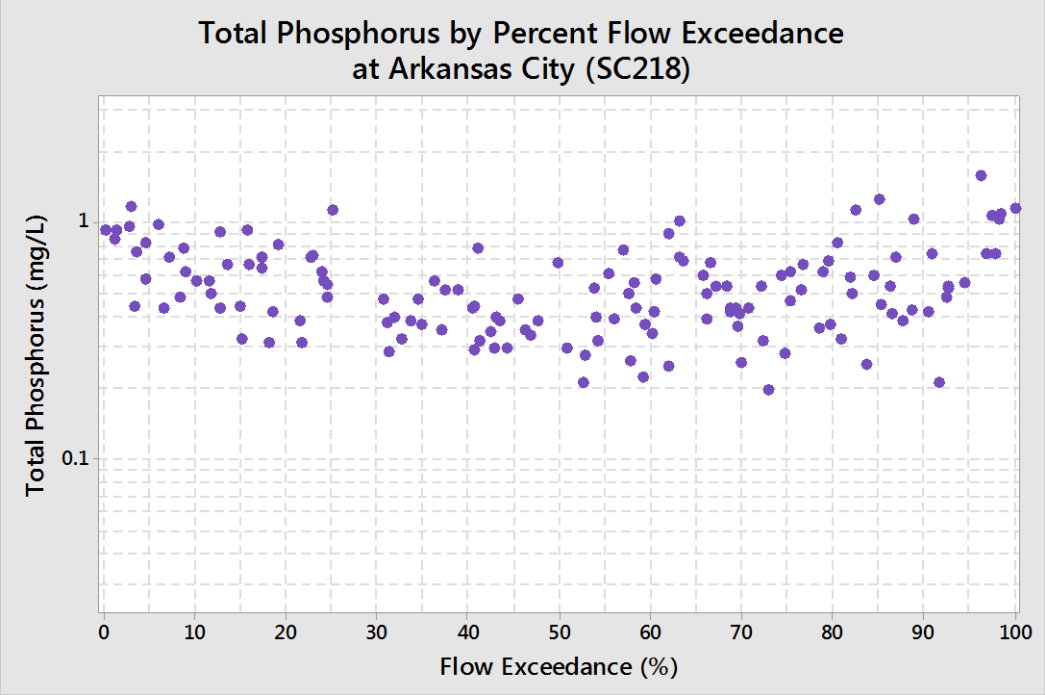
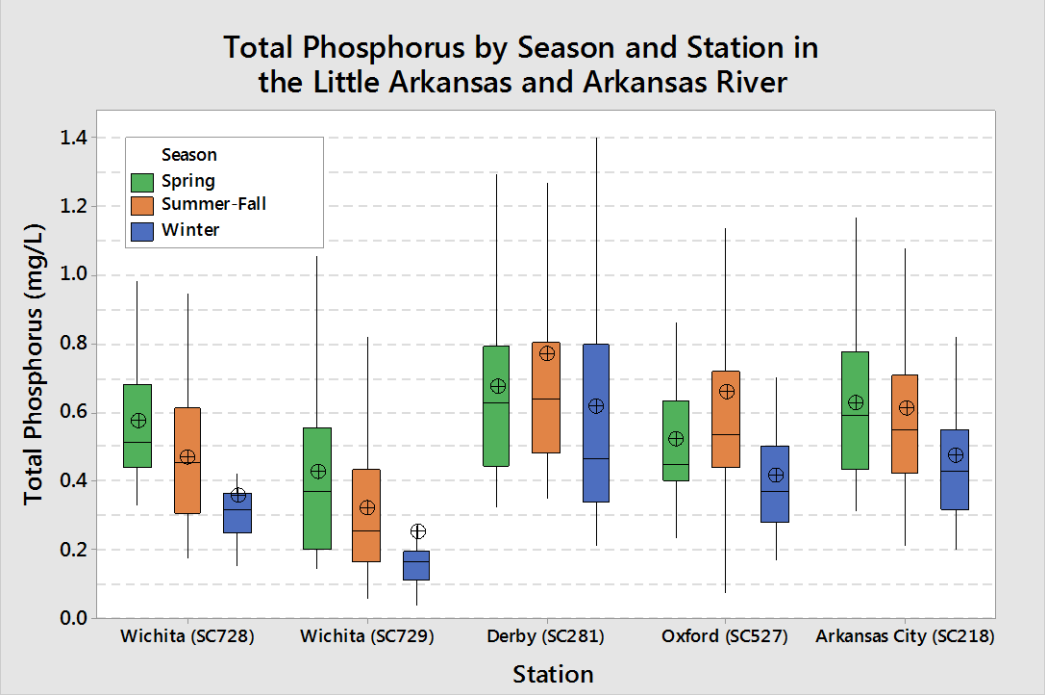


Figure 24. Total phosphorus by percent flow exceedance at Arkansas City (SC218) in the Arkansas River, March 20, 1990 to April 24, 2017.



Seasonally, spring (April through June) and summer-fall (July through October) have greater TP concentration means and medians than winter (November through March; **Figure 25**). Spring and winter seasonal variability correspond to higher streamflow during the spring month of June and lower streamflow during the winter months of December and January; however, Derby (SC281), Oxford (SC527), and Arkansas City (SC218) tend to have summer-fall TP concentration means and medians similar to or exceeding spring concentrations during the months of August, September, and October. These stations also have a wider range in winter TP concentrations than upstream SC stations, such as the Little Arkansas River at Wichita (SC728) and the Arkansas River at Wichita (SC729). These differences demonstrate effluent influence of TP concentrations observed at the downstream SC stations.

Figure 25. Total phosphorus by season and station in the Little Arkansas and Arkansas River, March 20, 1990 to April 24, 2017.



High annual mean (0.631 mg/L) and median (0.609 mg/L) TP concentrations in the Little Arkansas River at Wichita (SC728) occurred in 2008, the year with the highest rainfall total in Wichita at NOAA station USW00003928 over the TP period of record (**Figure 26**; **Table 7**). In 2008, the Arkansas River at Wichita (SC729) also had a high annual median TP concentration of 0.663 mg/L (**Figure 27**). Higher TP mean and median concentrations generally occurred in: 1991 at Derby (SC281), with a mean of 1.38 mg/L and a median of 1.33 mg/L (**Figure 28**); 1990 at Oxford (SC527), with a mean of 1.18 mg/L and a median of 1.36 mg/L (**Figure 29**); and 1990 near Arkansas City (SC218), with a mean of 1.03 mg/L and a median of 1.02 mg/L (**Figure 30**). Mean and median high TP concentration correspond to low mean and median annual streamflow at Derby (SC281), Oxford (SC527), and Arkansas City (SC218).

Figure 26. Annual mean and median total phosphorus at Wichita (SC728) in the Little Arkansas River, June 20, 2000 to April 18, 2017.

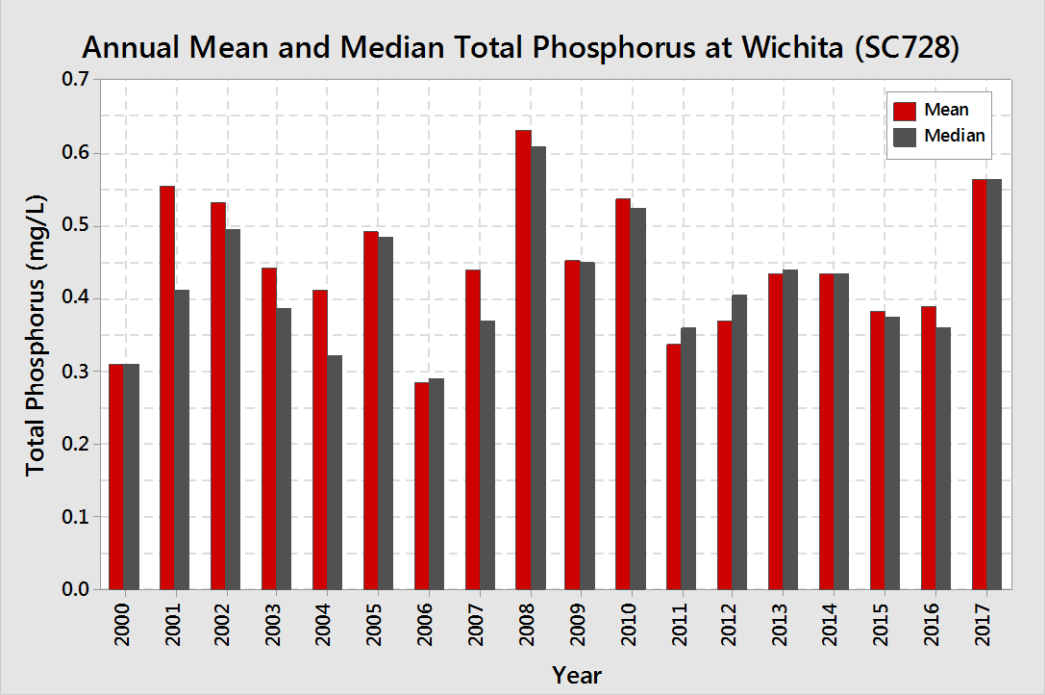


Figure 27. Annual mean and median total phosphorus at Wichita (SC729) in the Arkansas River, June 20, 2000 to April 24, 2017.

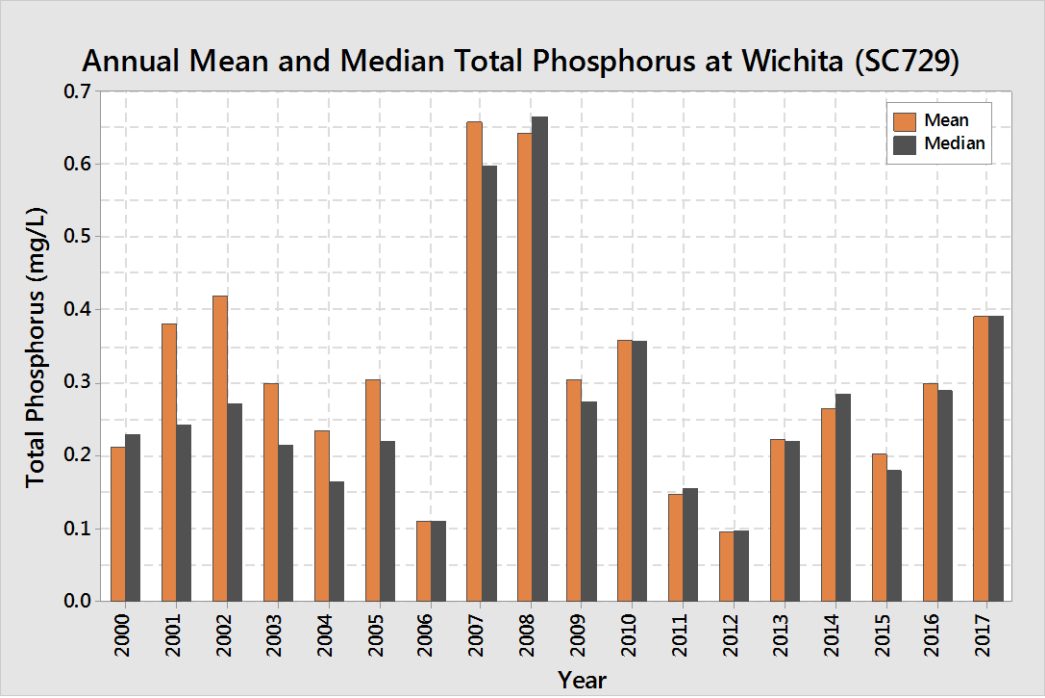


Figure 28. Annual mean and median total phosphorus at Derby (SC281) in the Arkansas River, March 20, 1990 to April 24, 2017.

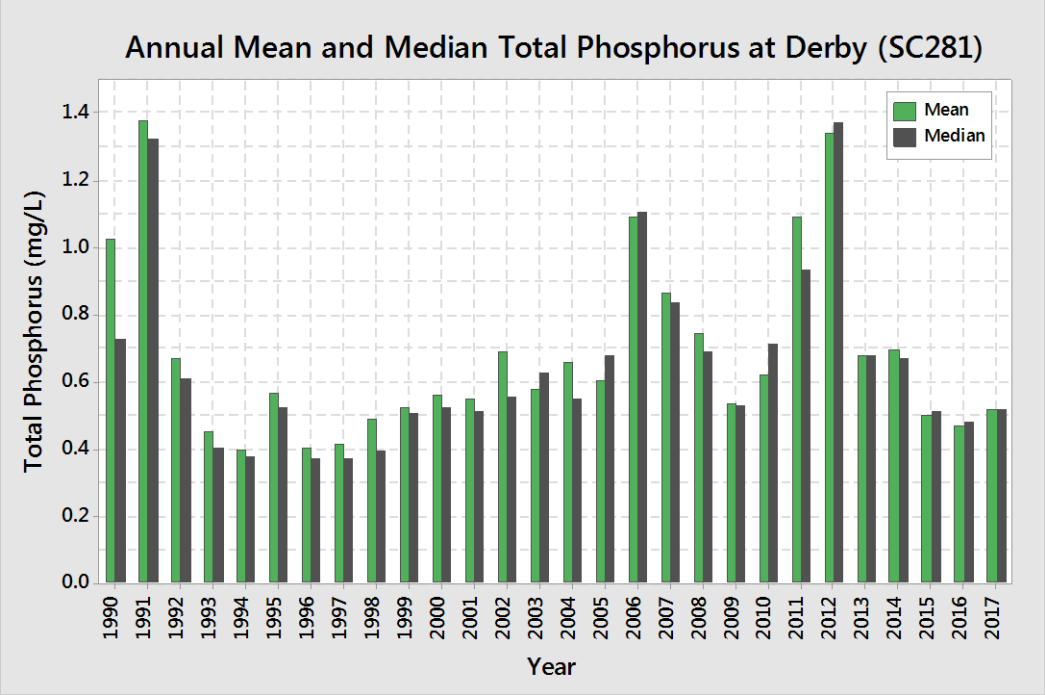


Figure 29. Annual mean and median total phosphorus at Oxford (SC527) in the Arkansas River, March 20, 1990 to April 24, 2017.

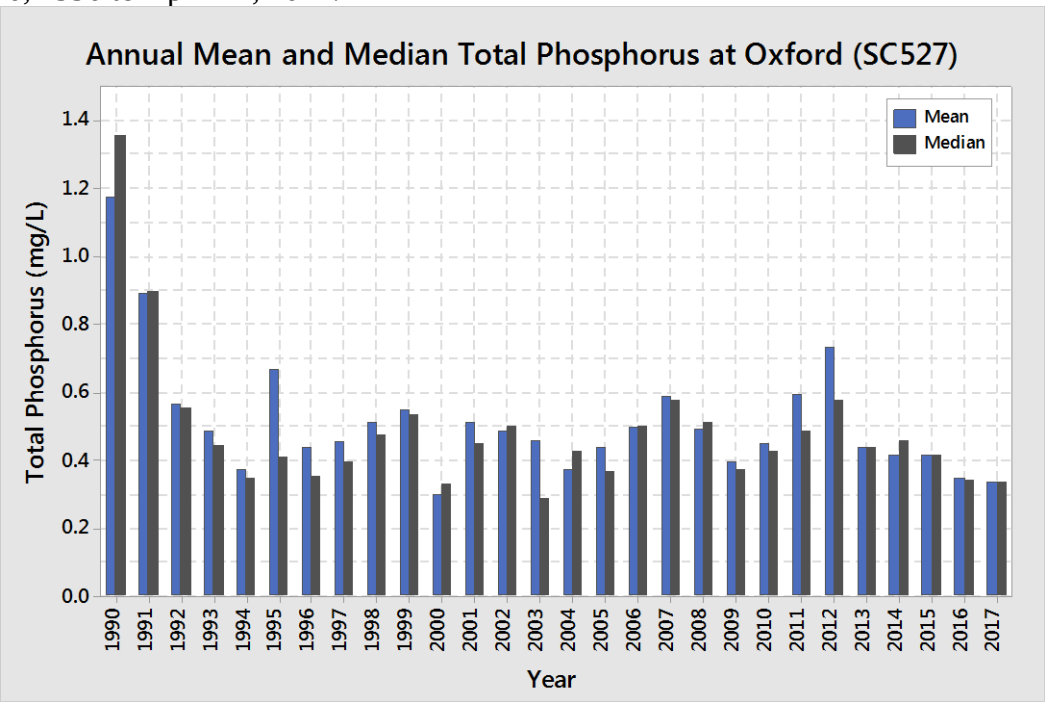
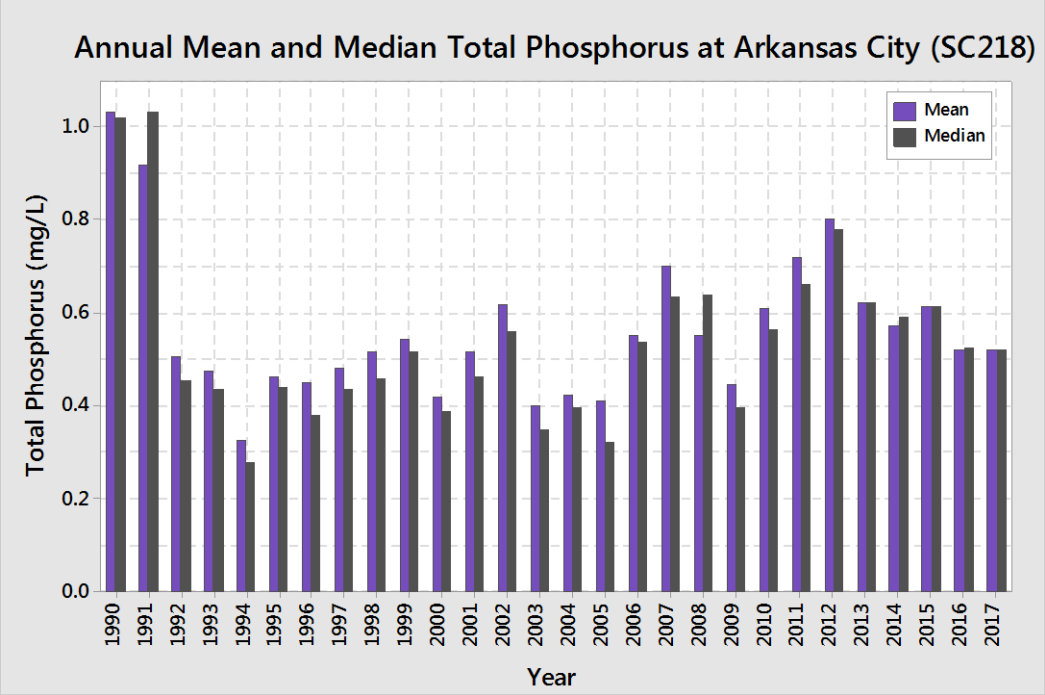


Figure 30. Annual mean and median total phosphorus at Arkansas City (SC218) in the Arkansas River, March 20, 1990 to April 24, 2017.



Low annual TP mean and median concentrations occurred in: 2006 at Little Arkansas River at Wichita (SC728), with a mean of 0.286 mg/L and median of 0.290 mg/L; 2012 at Arkansas River at Wichita (SC729), with a mean of 0.096 mg/L and median of 0.098 mg/L; and 2000 at Oxford (SC527), with a mean of 0.298 mg/L and a median of 0.330 mg/L. Mean and median low TP concentration correspond to low mean and median annual streamflow at the Little Arkansas River at Wichita (SC728) and the Arkansas River at Wichita (SC729). Meanwhile, stations at Derby (SC281) and near Arkansas City (SC218) both had low annual TP mean and median concentrations in 1994 (mean: 0.397 and 0.325 mg/L, respectively; median: 0.375 and 0.280 mg/L, respectively).

Table 7. Annual total phosphorus mean and median concentrations in the Little Arkansas and Arkansas River, March 20, 1990 to April 24, 2017. Values with no data are denoted with a – symbol.

Year	Total Phosphorus (mg/L)									
	Little Arkansas River at Wichita (SC728)		*Arkansas River at Wichita (SC729)*		*Arkansas River at Derby (SC281)*		*Arkansas River at Oxford (SC527)*		*Arkansas River at Arkansas City (SC218)*	
	Average	Median	Average	Median	Average	Median	Average	Median	Average	Median
1990	–	–	–	–	1.026	0.730	1.178	1.360	1.030	1.020
1991	–	–	–	–	1.380	1.325	0.893	0.895	0.917	1.030
1992	–	–	–	–	0.668	0.610	0.563	0.555	0.505	0.455
1993	–	–	–	–	0.452	0.405	0.483	0.440	0.473	0.435
1994	–	–	–	–	0.397	0.375	0.373	0.345	0.325	0.280
1995	–	–	–	–	0.567	0.525	0.666	0.412	0.462	0.438
1996	–	–	–	–	0.406	0.374	0.436	0.353	0.452	0.379
1997	–	–	–	–	0.416	0.369	0.451	0.392	0.483	0.436
1998	–	–	–	–	0.488	0.391	0.511	0.475	0.519	0.457
1999	–	–	–	–	0.522	0.507	0.548	0.534	0.544	0.515
2000	0.310	0.310	0.213	0.230	0.562	0.520	0.298	0.330	0.418	0.390
2001	0.553	0.413	0.380	0.243	0.550	0.511	0.514	0.446	0.516	0.462
2002	0.532	0.494	0.419	0.271	0.692	0.556	0.485	0.501	0.618	0.558
2003	0.441	0.389	0.299	0.215	0.577	0.628	0.459	0.287	0.399	0.350
2004	0.412	0.324	0.234	0.165	0.660	0.548	0.370	0.425	0.425	0.398
2005	0.493	0.485	0.304	0.220	0.604	0.678	0.435	0.368	0.412	0.320
2006	0.286	0.290	0.111	0.111	1.091	1.105	0.498	0.501	0.552	0.535
2007	0.440	0.369	0.657	0.598	0.864	0.838	0.585	0.579	0.700	0.633
2008	0.631	0.609	0.642	0.663	0.744	0.690	0.491	0.512	0.552	0.638
2009	0.453	0.449	0.304	0.274	0.533	0.527	0.392	0.374	0.446	0.397
2010	0.538	0.524	0.359	0.357	0.620	0.710	0.448	0.428	0.612	0.563
2011	0.338	0.361	0.148	0.154	1.089	0.935	0.591	0.486	0.721	0.663
2012	0.369	0.405	0.096	0.098	1.342	1.372	0.732	0.576	0.802	0.778
2013	0.436	0.440	0.222	0.220	0.677	0.678	0.437	0.437	0.621	0.623
2014	0.435	0.435	0.265	0.285	0.698	0.670	0.415	0.460	0.570	0.590
2015	0.383	0.375	0.203	0.180	0.500	0.510	0.418	0.415	0.613	0.615
2016	0.390	0.360	0.300	0.290	0.470	0.480	0.348	0.340	0.523	0.525
2017	0.565	0.565	0.390	0.390	0.515	0.515	0.335	0.335	0.520	0.520
1990 to 1999	–	–	–	–	*0.632*	*0.456*	*0.610*	*0.457*	*0.571*	*0.446*
2000 to 2017	*0.445*	*0.409*	*0.308*	*0.237*	*0.710*	*0.649*	*0.458*	*0.432*	*0.557*	*0.547*

Individual TP samples can indicate sources of TP loading in these watersheds by comparing samples collected on concurrent days at upstream and downstream stations. Samples collected near upstream Wichita (SC729) and downstream Derby (SC281) indicate that higher TP concentrations are detected near Derby (SC281; **Figure 31**). Comparison of same day samples collected near upstream Derby (SC281) and downstream at Oxford (SC527) indicate that TP concentrations undergo some dilution between Derby and Oxford (**Figure 32**). Same day samples collected at upstream Oxford (SC527) and downstream Arkansas City (SC218) show TP concentrations generally increase between these watersheds (**Figure 33**).

Figure 31. Total phosphorus at upstream Wichita (SC729) versus downstream Derby (SC281) stations for concurrent day samples in the Arkansas River, June 20, 2000 to April 24, 2017.

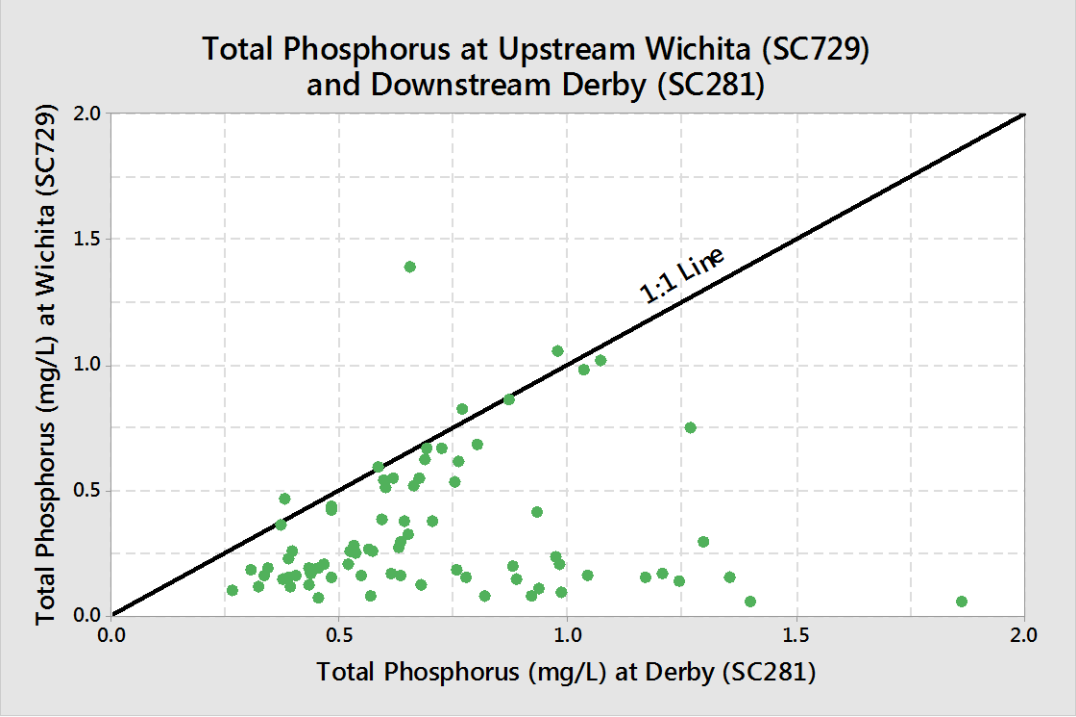


Figure 32. Total phosphorus at upstream Derby (SC281) versus downstream Oxford (SC527) stations for concurrent day samples in the Arkansas River, March 20, 1990 to April 24, 2017.

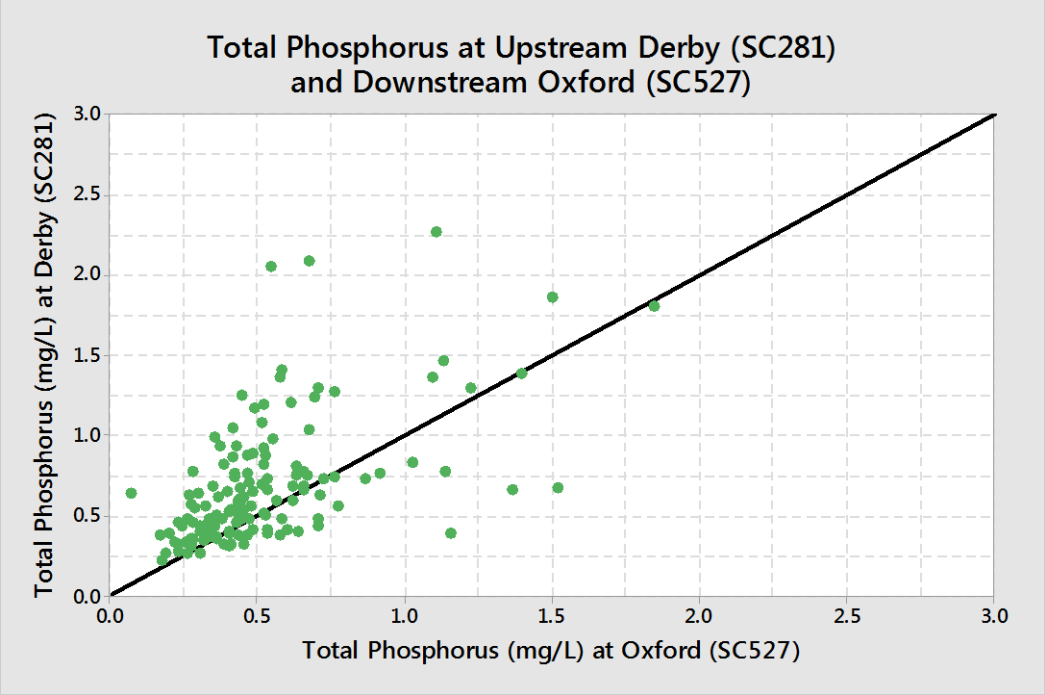
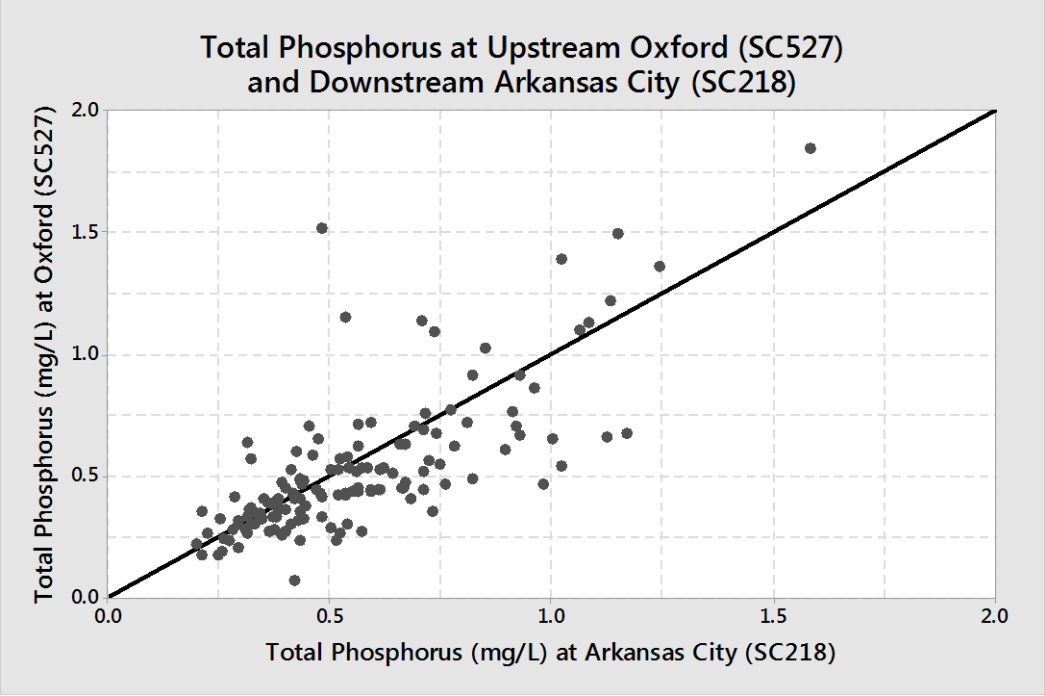


Figure 33. Total phosphorus at upstream Oxford (SC527) versus downstream Arkansas City (SC218) stations for concurrent day samples in the Arkansas River, March 20, 1990 to April 24, 2017.



Total Phosphorus and Water Quality Parameters: Orthophosphate (OP) is the soluble portion of TP that is readily available for biological use. It is commonly found in higher concentrations in the effluent of wastewater treatment plants (WWTP) and can therefore be indicative of point source contributions of phosphorus in streams. Only samples measuring above the reporting limit are analyzed and discussed here, resulting in a left censored data set which may overestimate true OP concentration means. In addition, reporting limits for OP have changed throughout the period of record: 0.01 mg/L from 1995-1996, 0.02 mg/L from 1997 to February 2002, and 0.25 from March 2002 to 2017.

Despite these limitations and variability, a trend similar to that seen in TP concentrations is displayed in detected OP concentrations. The highest percentage of samples detected above the reporting limit and overall censored mean concentration occurs at Derby (SC281; **Table 8**). Orthophosphate percentage of samples detected above the reporting limit and overall censored mean concentrations decline at Oxford (SC527) before increasing again near Arkansas City (SC218). The lowest percentage of samples detected above the reporting limit and overall censored mean concentrations occur at Little Arkansas River at Wichita (SC728) and Arkansas River at Wichita (SC729).

Table 8. Detected orthophosphate (OP) samples separated by reporting limit increases in the Little Arkansas and Arkansas River, February 7, 1995 to November 23, 2015. Description: Mean - average of OP values greater than the reporting limit; - - no data; N - number of OP values greater than the reporting limit; Sample Percent - percentage of total samples with OP greater than the reporting limit

Station	Sample Information	Period of Record			
		1995-1996 (0.01 mg/L)	1997-Feb. 2002 (0.02 mg/L)	Mar. 2002-2017 (0.25 mg/L)	1990-2017
Little Arkansas River at Wichita (SC728)	Mean (mg/L)	-	0.170	0.357	0.341
	N	-	2	22	24
	Sample Percent	-	20	33	32
Arkansas River at Wichita (SC729)	Mean (mg/L)	-	0.035	0.325	0.277
	N	-	2	10	12
	Sample Percent	-	20	15	15
Arkansas River at Derby (SC281)	Mean (mg/L)	0.188	0.170	0.598	0.474
	N	11	8	45	64
	Sample Percent	92	50	67	67
Arkansas River at Oxford (SC527)	Mean (mg/L)	0.162	0.122	0.381	0.297
	N	11	6	30	47
	Sample Percent	92	38	45	50
Arkansas River at Arkansas City (SC218)	Mean (mg/L)	0.166	0.238	0.414	0.335
	N	11	6	31	48
	Sample Percent	92	38	46	51

Detection of OP is least frequent at the upstream Arkansas River at Wichita (SC729) and more frequent at the Little Arkansas River at Wichita (SC728) and the Arkansas River at Derby (SC281), Oxford (SC527), and Arkansas City (SC218; **Figures 34-38)**. There are individual instances of OP concentrations exceeding 0.5 mg/L for the period of record at Derby (SC281),

Oxford (SC527), and Arkansas City (SC218), with OP values at Derby (SC281) even exceeding 1.5 mg/L. There are no individual instances of OP concentrations exceeding 0.5 mg/L at Arkansas River at Wichita (SC729) and a couple instances at Little Arkansas River at Wichita (SC728). The more frequent detections of OP at Derby (SC281), Oxford (SC527), and Arkansas City (SC218), as well as the higher concentration of OP at these stations, is indicative of the location and contribution of WWTP effluent.

Further indication of WWTP influence is especially evident during low flow conditions (**Figure 39**). Downstream stations at Derby (SC281), Oxford (SC527), and Arkansas City (SC218) display a trend of increasing OP concentrations during lower flow conditions, with concentrations double or triple those seen at higher flow conditions. Meanwhile, the tributary station at Little Arkansas River at Wichita (SC728) and the upstream station Arkansas River at Wichita (SC729) have OP concentrations that remain relatively stable throughout all flow conditions.

Figure 34. Orthophosphate and total phosphorus samples measuring greater than the reporting limit at Wichita (SC728) in the Little Arkansas River, June 20, 2000 to November 23, 2015.

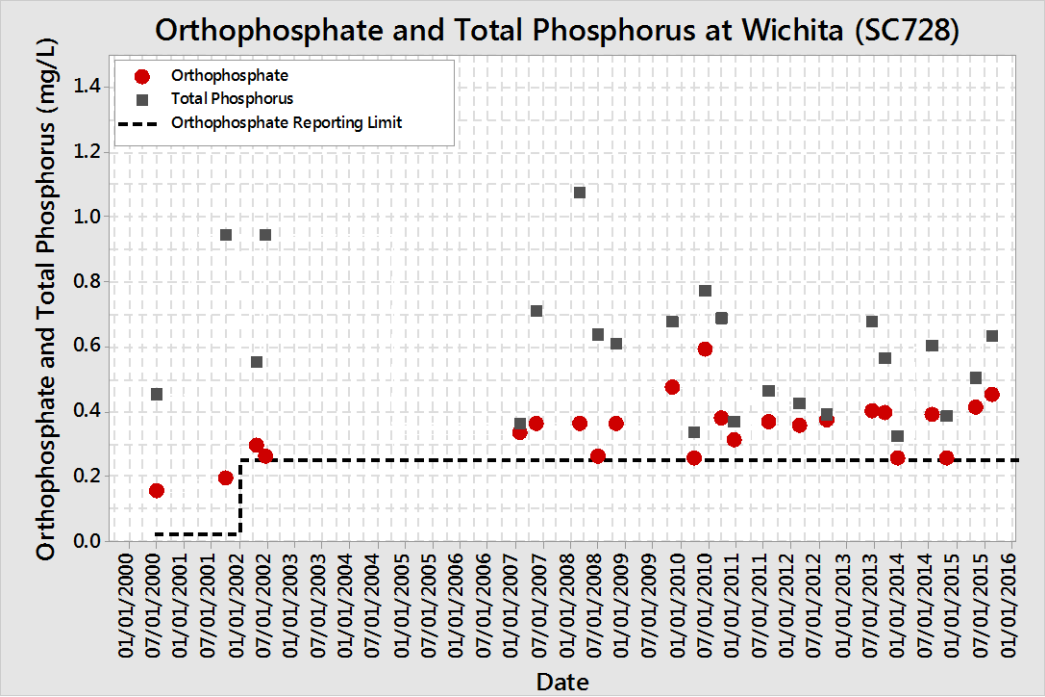


Figure 35. Orthophosphate and total phosphorus samples measuring greater than the reporting limit at Wichita (SC729) in the Arkansas River, September 18, 2001 to November 23, 2015.

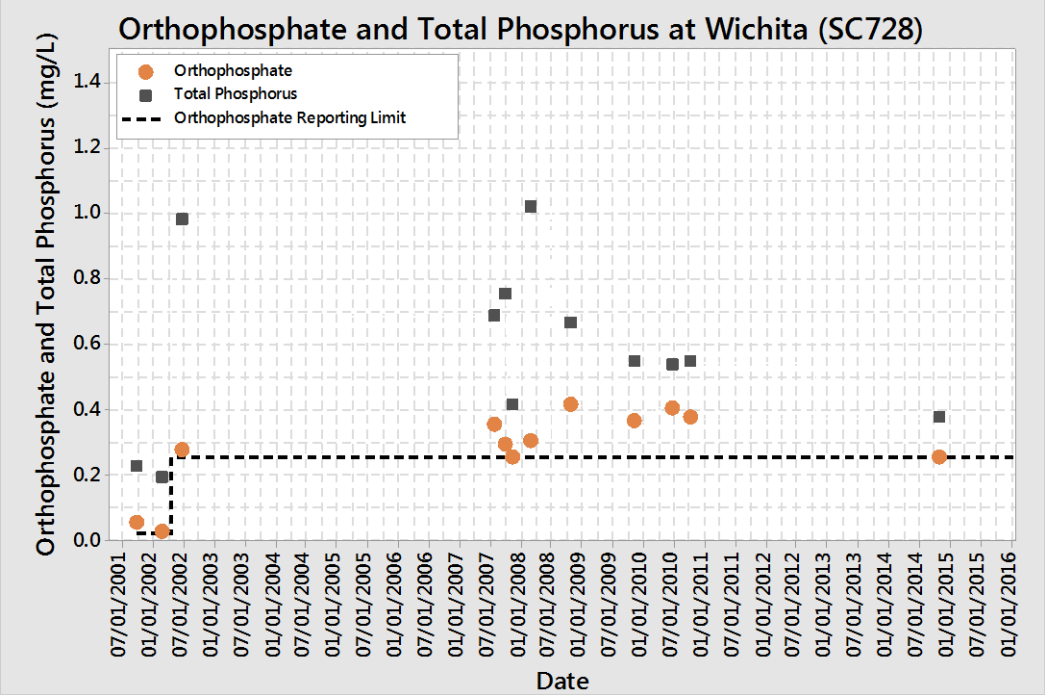


Figure 36. Orthophosphate and total phosphorus samples measuring greater than the reporting limit at Derby (SC281) in the Arkansas River, February 7, 1995 to November 23, 2015.

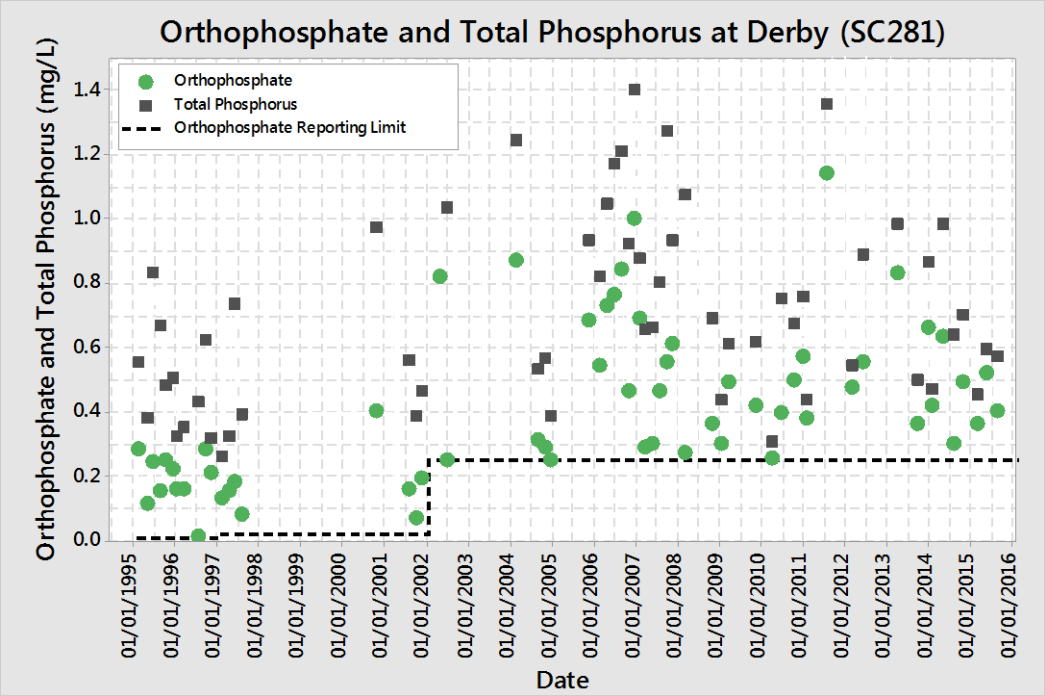


Figure 37. Orthophosphate and total phosphorus samples measuring greater than the reporting limit at Oxford (SC527) in the Arkansas River, February 7, 1995 to November 23, 2015.

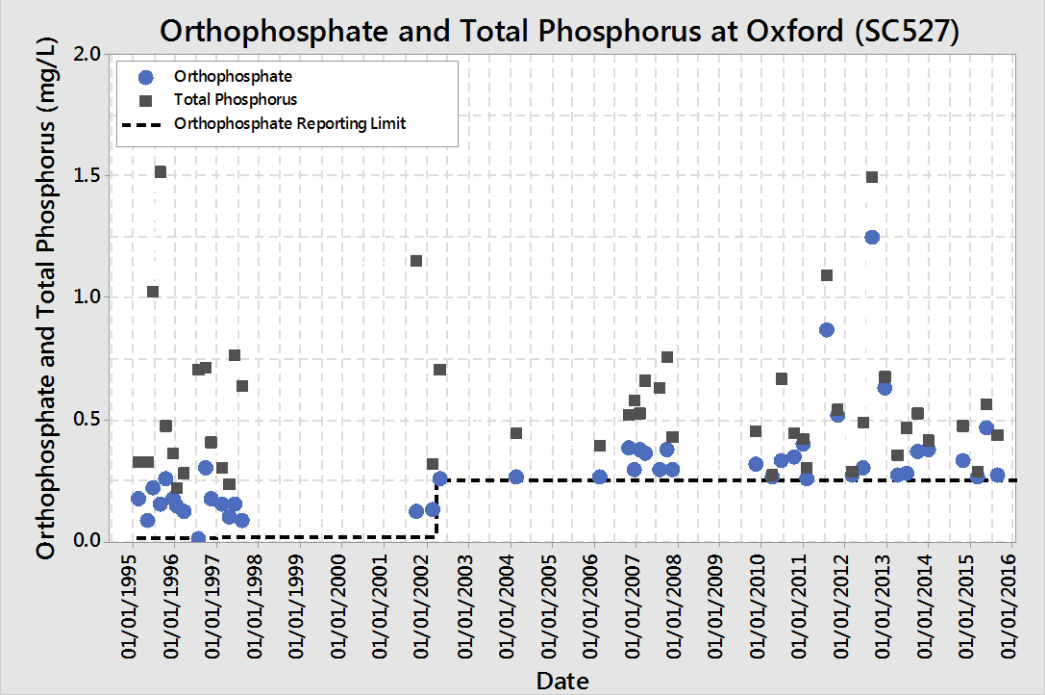


Figure 38. Orthophosphate and total phosphorus samples measuring greater than the reporting limit collected at Arkansas City (SC218) in the Arkansas River, February 7, 1995 to November 23, 2015.

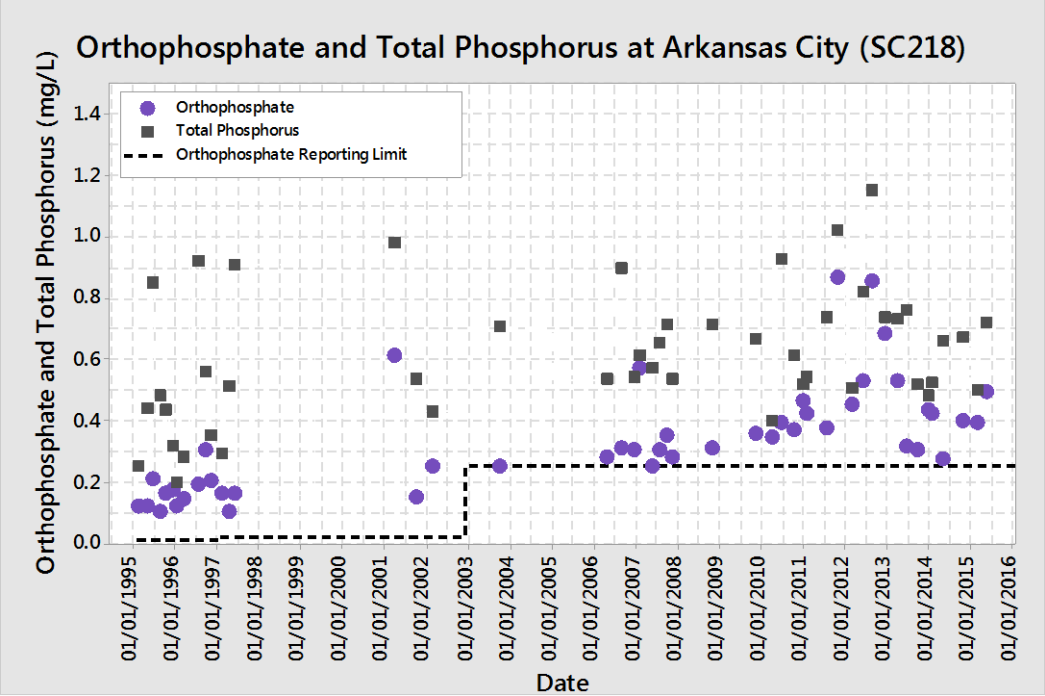
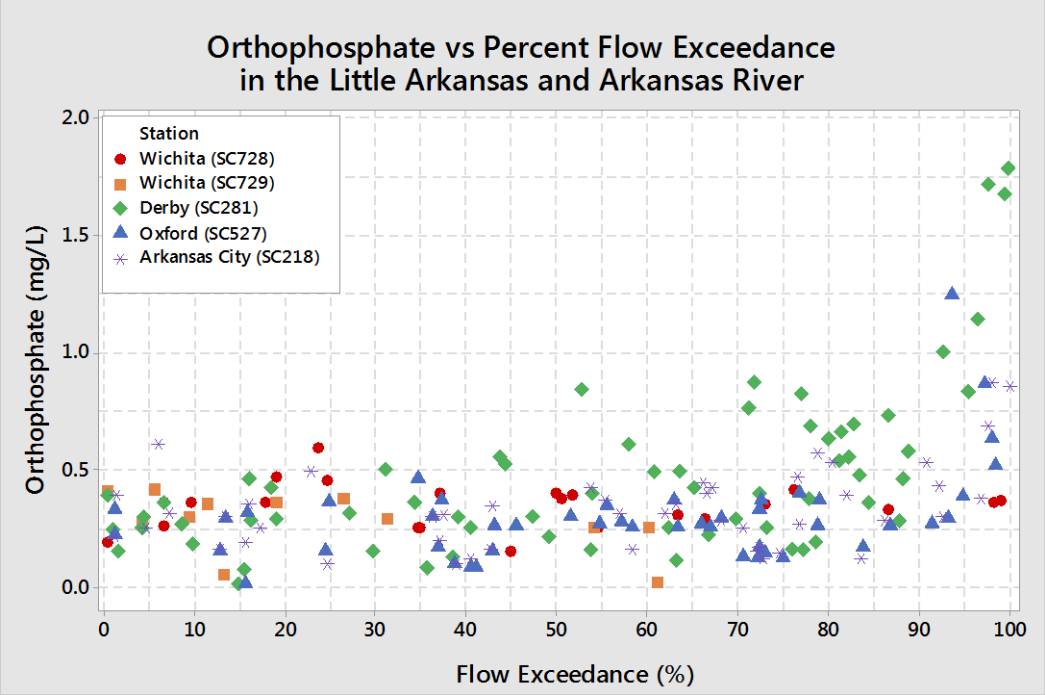


Figure 39. Orthophosphate versus percent flow exceedance in the Little Arkansas and Arkansas River, February 7, 1995 to April 24, 2017.



Phosphorus has a high affinity for fixation in soils, where it is adsorbed from soil solution. Erosion of phosphorus-laden soil particles is a common means for phosphorus to enter streams. Due to the low concentration of phosphorus in freshwater, it can then be desorbed. This propensity for adsorbtion and desorbtion to soil particles creates a relationship between TP and total suspended solids (TSS) that is evident at all stations in the Arkansas River (**Figures 40-44**), particularly at the tributary Little Arkansas River at Wichita (SC728) and upstream Arkansas River at Wichita (SC729) stations (**Figures 40-41**). This relationship is especially well-defined during higher (0-25%) and normal (26-75%) flow conditions for all stations except Derby (SC281), which loses the relationship at normal flow conditions (**Figure 42**). During lower (76-100%) flow conditions, the relationship between TP and TSS becomes weaker and is virtually non-existent at Derby (SC281), Oxford (SC527), and Arkansas City (SC218; **Figures 42-44**); these stations are more strongly influenced by point source contributions of TP, resulting in a loss of correlation as TP concentration increases irrespective of TSS concentration.

Figure 40. Total phosphorus versus total suspended solids and total phosphorus versus total suspended solids by percent flow exceedance at Wichita (SC728) in the Little Arkansas River, June 20, 2000 to April 18, 2017.

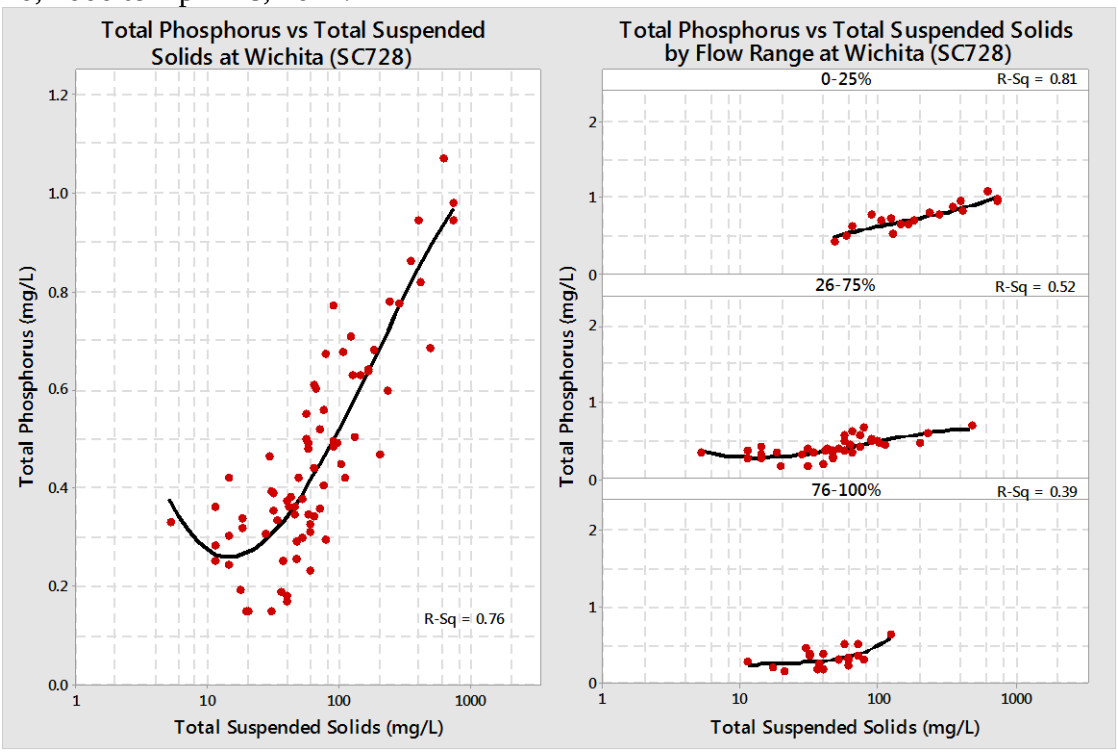


Figure 41. Total phosphorus versus total suspended solids and total phosphorus versus total suspended solids by percent flow exceedance at Wichita (SC729) in the Arkansas River, June 20, 2000 to April 24, 2017.

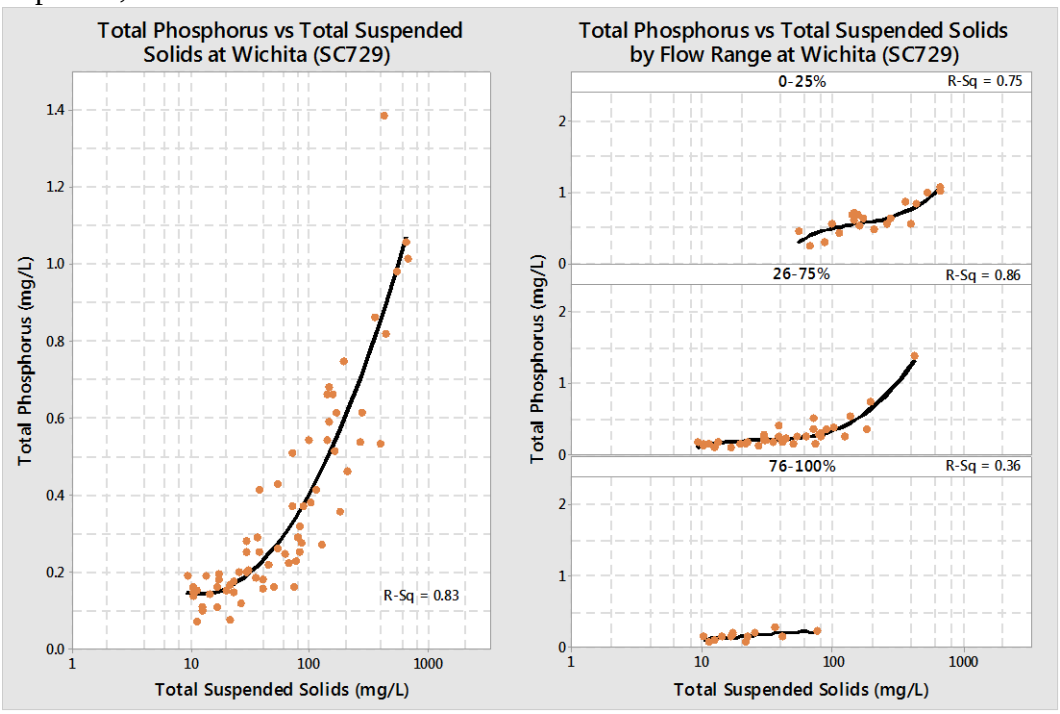


Figure 42. Total phosphorus versus total suspended solids and total phosphorus versus total suspended solids by percent flow exceedance at Derby (SC281) in the Arkansas River, March 20, 1990 to April 24, 2017.

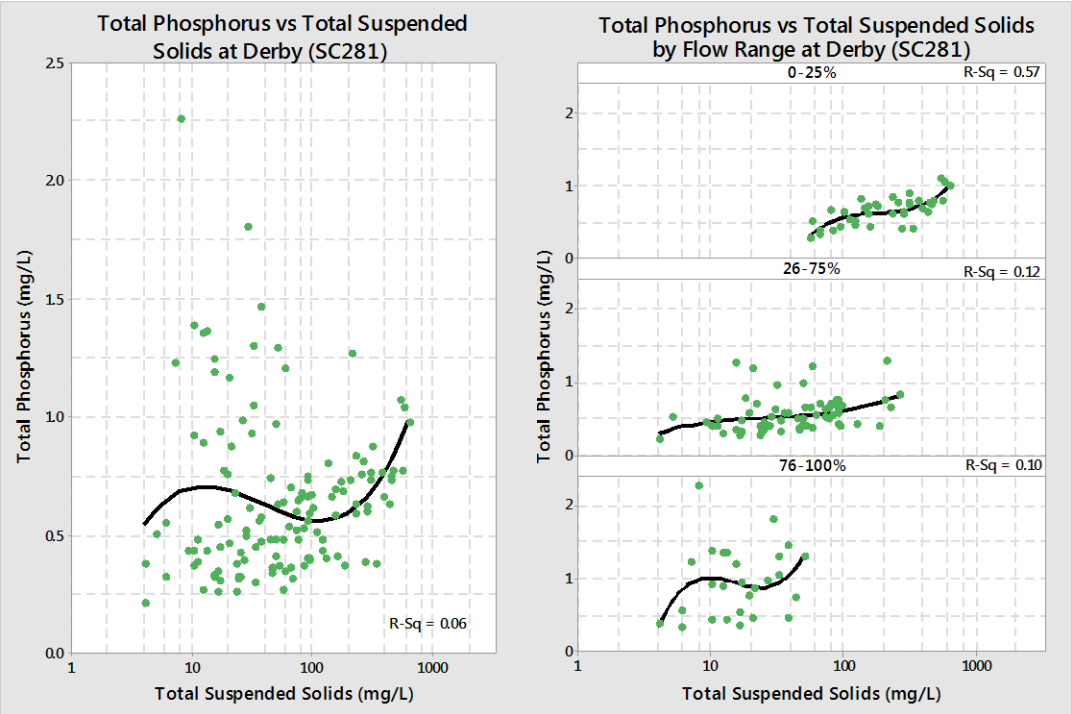


Figure 43. Total phosphorus versus total suspended solids and total phosphorus versus total suspended solids by percent flow exceedance at Oxford (SC527) in the Arkansas River, March 20, 1990 to April 24, 2017.

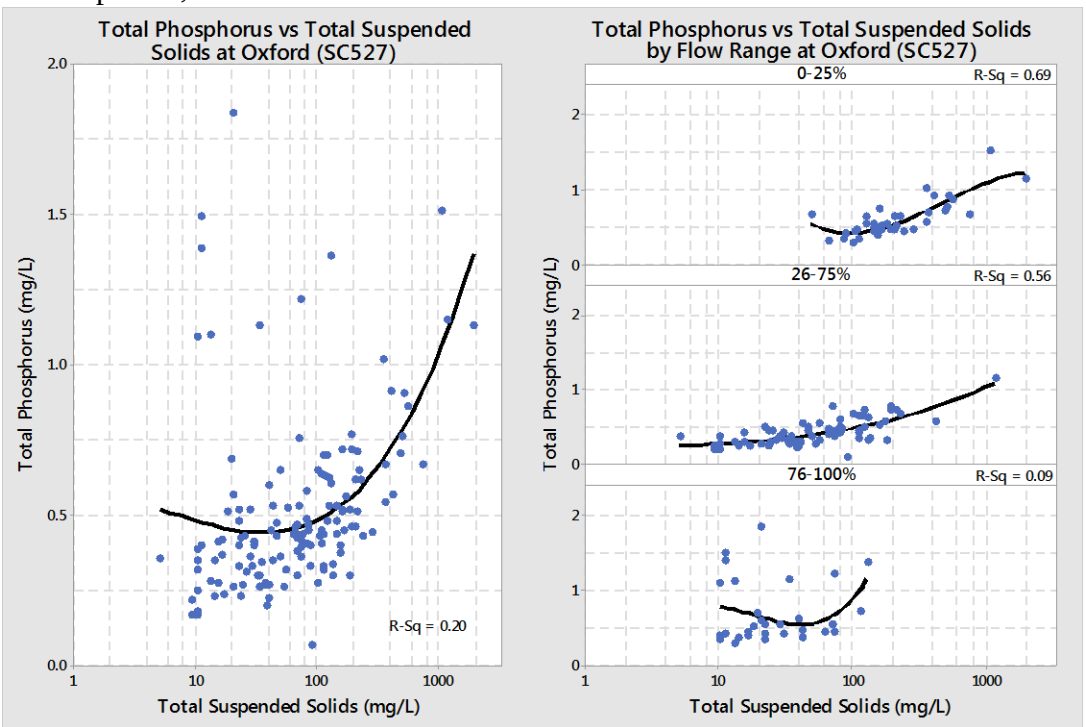
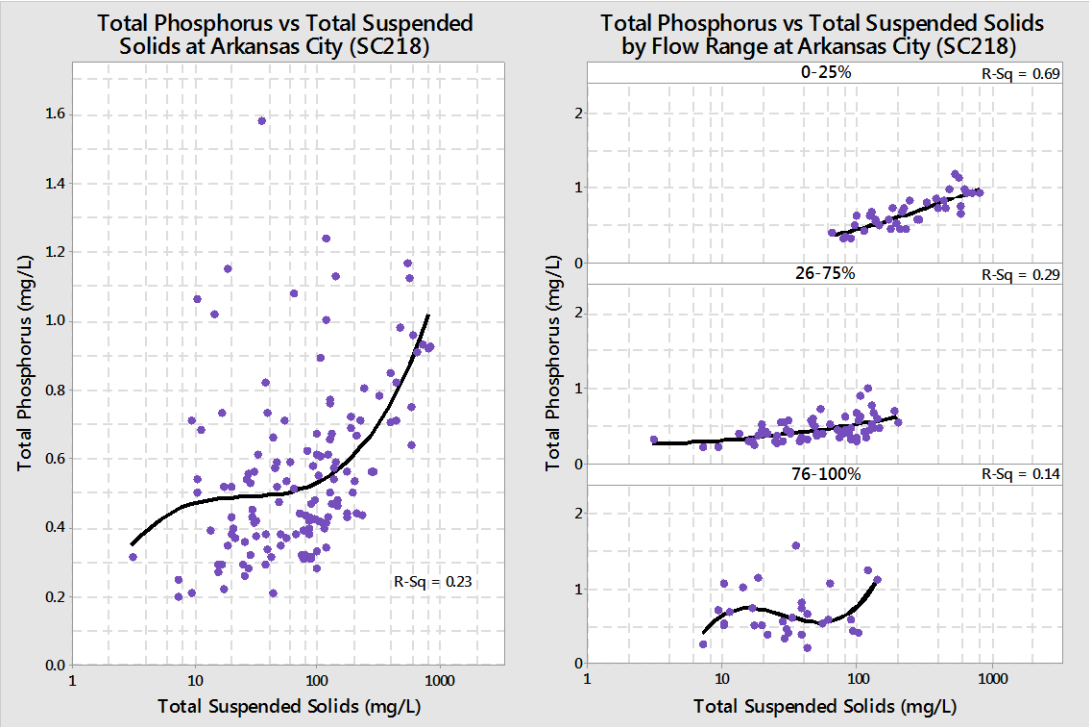


Figure 44. Total phosphorus versus total suspended solids and total phosphorus versus total suspended solids by percent flow exceedance at Arkansas City (SC218) in the Arkansas River, March 20, 1990 to April 24, 2017.



Total Phosphorus and Major Point Source Contributions: The previously discussed analyses generally indicate point source influences in the Little Arkansas River at Wichita (SC728) and Arkansas River at Derby (SC281), Oxford (SC527), and Arkansas City(SC218). Significant TP contributions from point sources at these stations are predominantly due to major municipal WWTPs in urban areas, with the exception of an industrial WWTP near Arkansas City (SC218). The influence of these discharging WWTPs in the watershed was evaluated by comparing the monthly TP concentrations in the WWTPs' effluent to the monthly TP concentrations in the Little Arkansas and Arkansas River at the SC stations, where concomitant data were available.

The Little Arkansas River at Wichita (SC728) station is downstream of the Valley Center WWTP (**Figure 45**) and the Chisholm Creek Utility Authority WWTP (which serves several municipalities; **Figure 46**), both of which contribute TP to the lower reaches of the Little Arkansas River. The Wichita WWTP, upstream of Derby (SC281), is the largest facility discharging to the Arkansas River, as can be seen in increasing TP concentrations evident at Derby (SC281; **Figure 47**). Downstream of Derby (SC281), the Derby WWTP (**Figure 48**) and Mulvane WWTP (**Figure 49**) also exhibit TP concentrations that coincide with TP concentrations at Oxford (SC527); however, the Mulvane WWTP loses this trend in 2013 due to WWTP upgrades, resulting in substantially lower TP contributions. The station near Arkansas City (SC218) is upstream of the Arkansas City WWTP but downstream of Creekstone Farms, a meat processing plant along the Arkansas River (**Figure 50**). As with municipal WWTPs, TP concentrations tend to coincide between Creekstone Farms and Arkansas City (SC218).

Figure 45. Total phosphorus effluent from Valley Center Wastewater Treatment Plant (NPDES Permit #K0099074) contributed to the Little Arkansas River upstream of the Little Arkansas River at Wichita (SC728), May 2009 to April 2017.

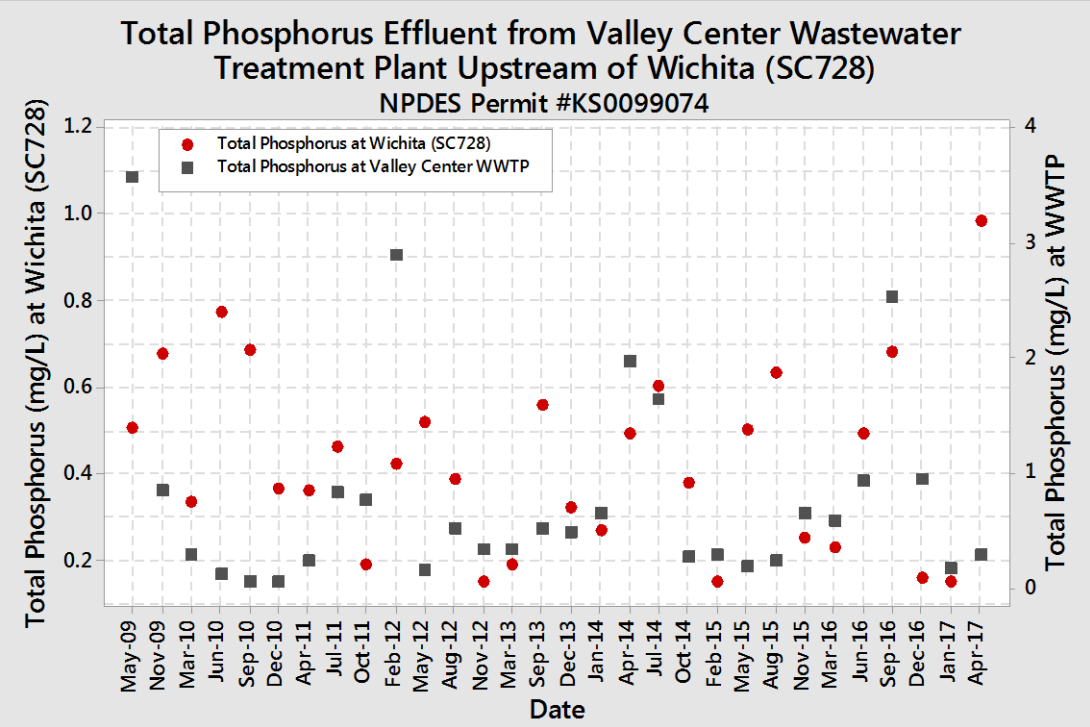


Figure 46. Total phosphorus effluent from Chisholm Creek Utility Wastewater Treatment Plant (NPDES Permit #KS0089176) contributed to the Little Arkansas River upstream of the Little Arkansas River at Wichita (SC728), January 2003 to April 2017.

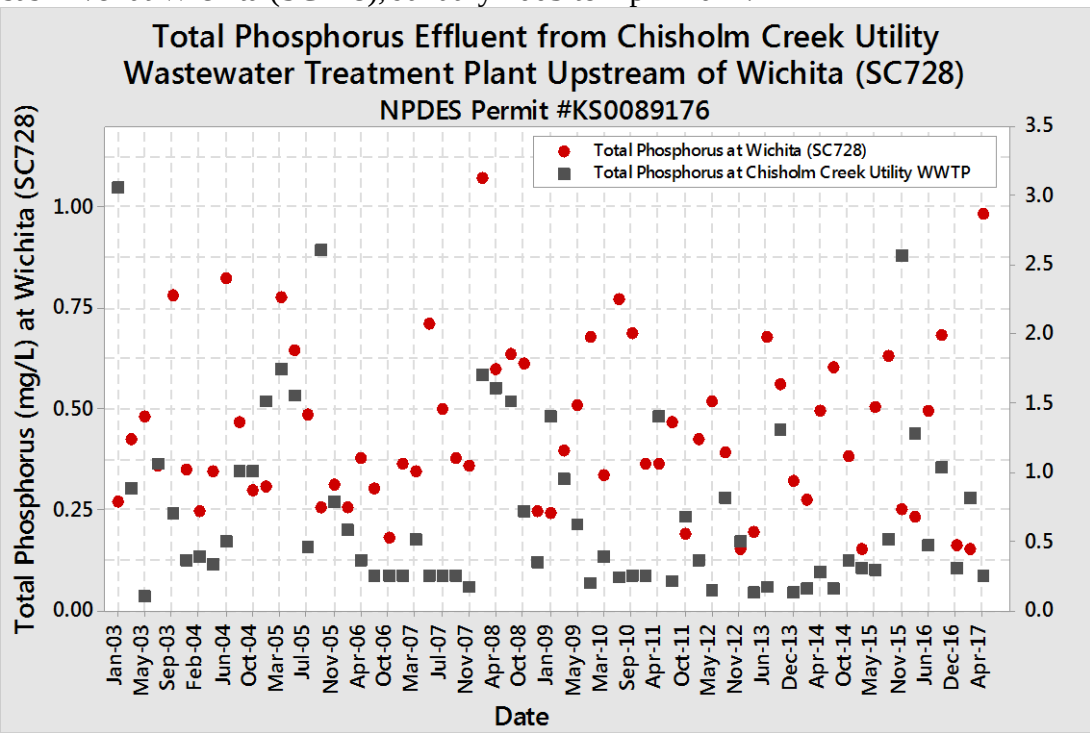


Figure 47. Total phosphorus effluent from Wichita Wastewater Treatment Plant (NPDES Permit #KS0043036) contributed to the Arkansas River upstream of Derby (SC281), January 2003 to April 2017.

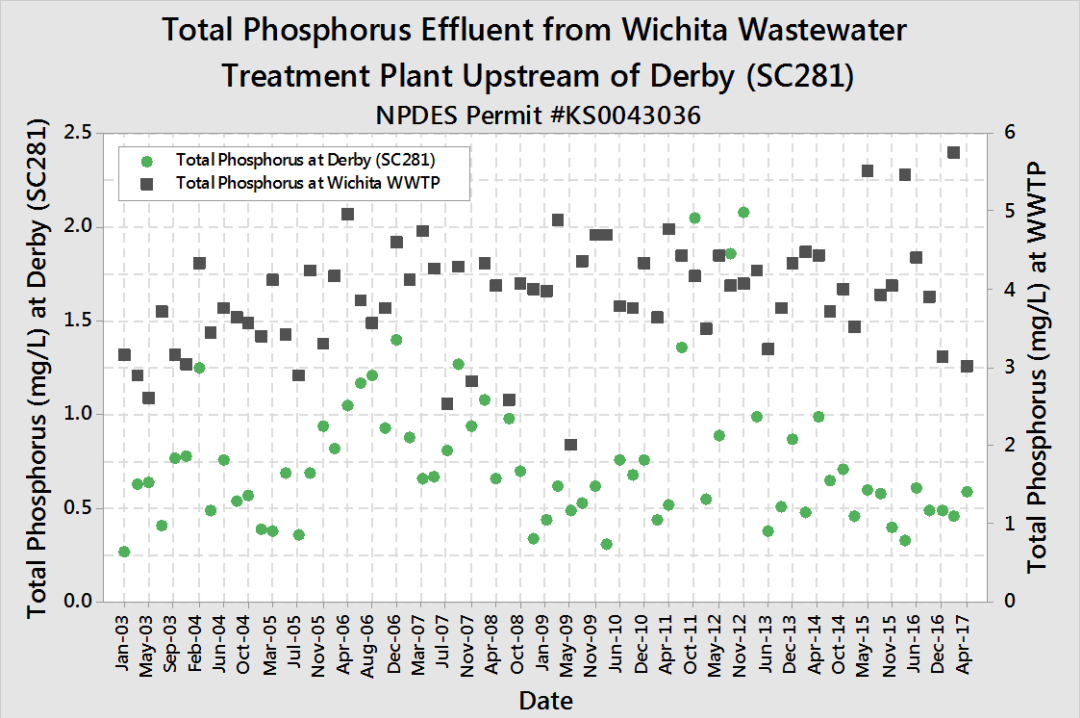


Figure 48. Total phosphorus effluent from Derby Wastewater Treatment Plant (NPDES Permit #KS0050377) contributed to the Arkansas River upstream of Oxford (SC527), January 2003 to April 2017.

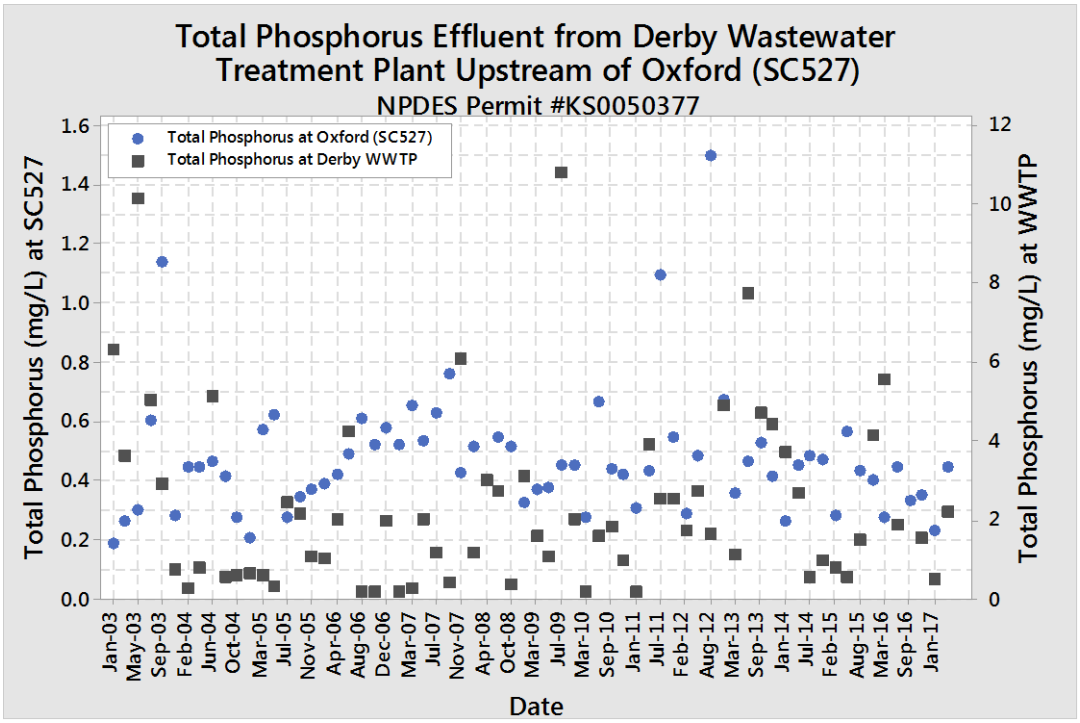


Figure 49. Total phosphorus effluent from Mulvane Wastewater Treatment Plant (NPDES Permit #KS0098418) contributed to the Arkansas River upstream of Oxford (SC527), August 2006 to April 2017.

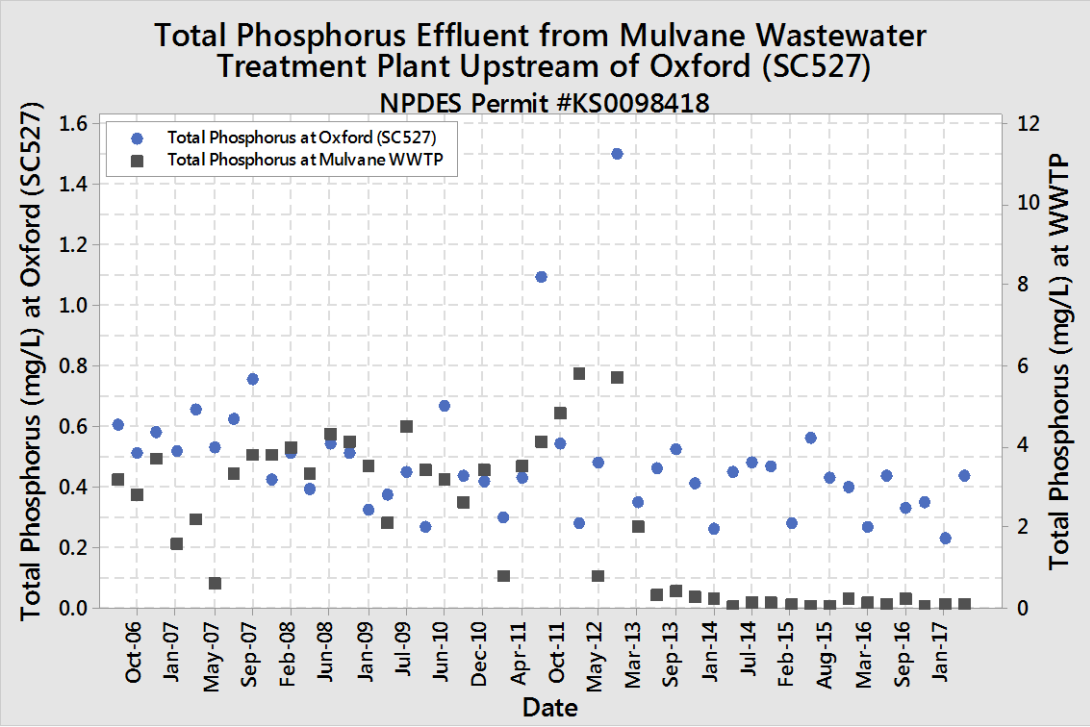
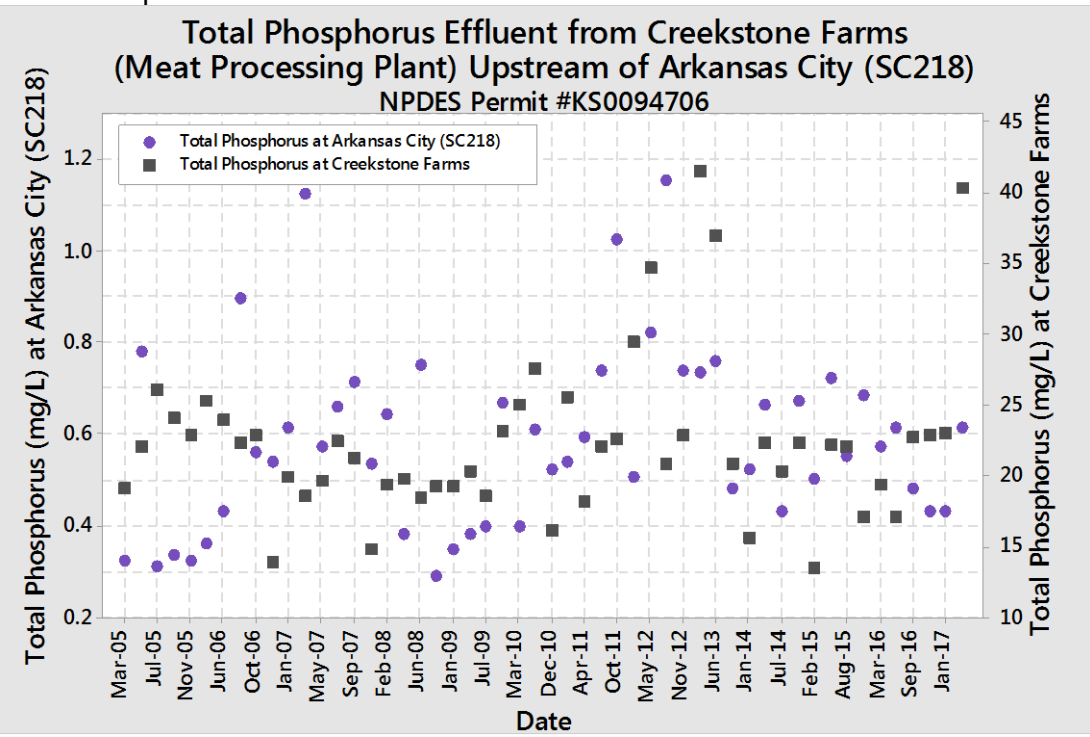


Figure 50. Total phosphorus effluent from Creekstone Farms (meat processing plant; NPDES Permit #KS0094706) contributed to the Arkansas River upstream of Arkansas City (SC218), March 2005 to April 2017.



Total Phosphorus and Biological Indicators: The narrative criteria of the Kansas Surface Water Quality Standards are based on conditions of the prevailing biological community. Excessive primary productivity may be indicated by extreme shifts in dissolved oxygen (DO), dissolved oxygen saturation (DO saturation), and pH as the chemical reactions of photosynthesis and respiration alter the ambient levels of oxygen and acid-base balance of the stream. These extreme shifts, in turn, can result in undesirable regime shifts in the biological community within the stream.

Dissolved oxygen and temperature are inversely related at all sites in the Arkansas River (**Figures 51-55**). This corresponds to seasonal changes in DO and temperature, where low mean DO concentrations occur in spring and summer-fall, when temperatures are highest, and high mean DO concentrations occur in winter, when temperatures are lowest (**Table 9**). This relationship is expected because oxygen becomes less soluble in water as temperatures increase. However, the weakest correlations occur at Derby (SC281), Oxford (SC527), and Arkansas City (SC218), where DO concentrations become more variable at higher temperatures and can even reach or exceed concentrations seen at much lower temperatures (**Figures 53-55**). Over the period of record, there are three DO excursions at Little Arkansas River at Wichita (SC728; in June 2000, July 2011, and August 2012), two DO excursions at Derby (SC281; in August 1991 and July 1998), and one DO excursion near Arkansas City (SC218; in June 2008; **Figures 51, 53, and 55**).

Figure 51. Dissolved oxygen and the relationship between dissolved oxygen and temperature at SC728 in the Little Arkansas River, June 20, 2000 to April 18, 2017.

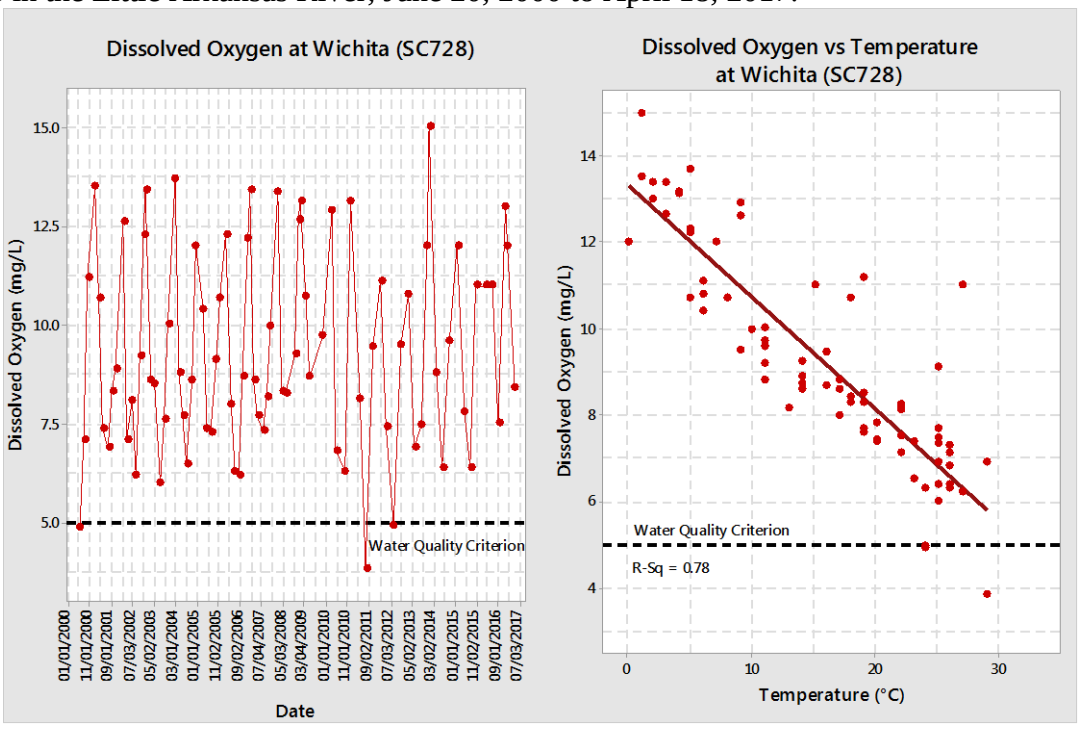


Figure 52. Dissolved oxygen and the relationship between dissolved oxygen and temperature at Wichita (SC729) in the Arkansas River, June 20, 2000 to April 24, 2017.

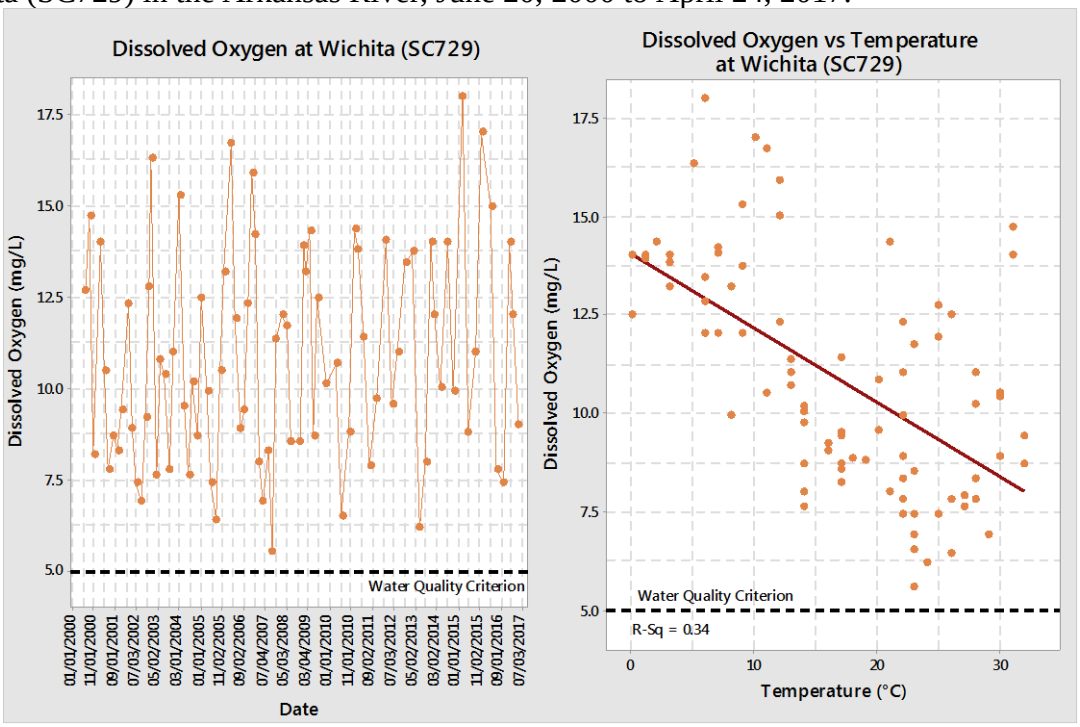


Figure 53. Dissolved oxygen and the relationship between dissolved oxygen and temperature at Derby (SC281) in the Arkansas River, March 20, 1990 to April 24, 2017.

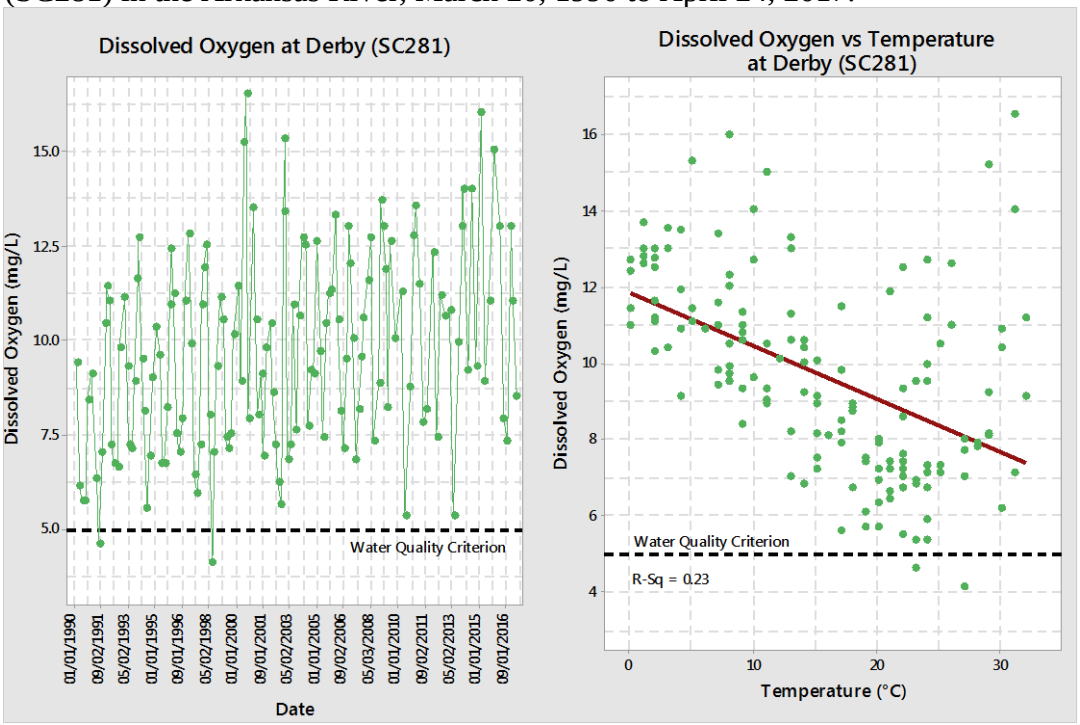


Figure 54. Dissolved oxygen and the relationship between dissolved oxygen and temperature at Oxford (SC527) in the Arkansas River, March 20, 1990 to April 24, 2017

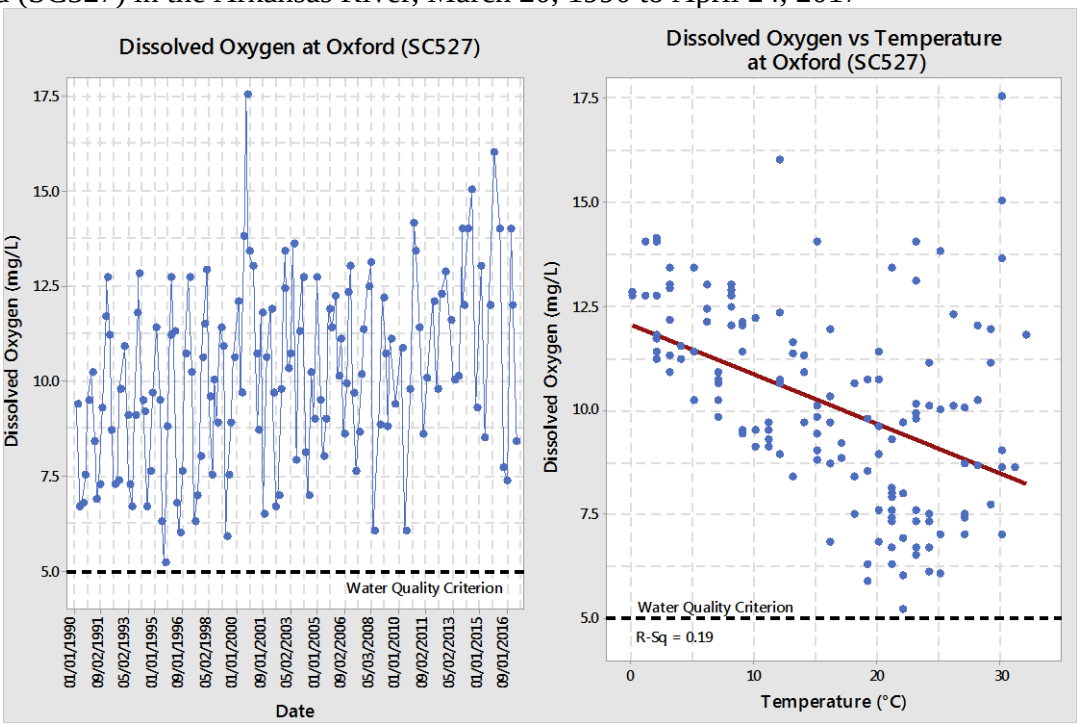


Figure 55. Dissolved oxygen and the relationship between dissolved oxygen and temperature at Arkansas City (SC218) in the Arkansas River, March 20, 1990 to April 24, 2017.

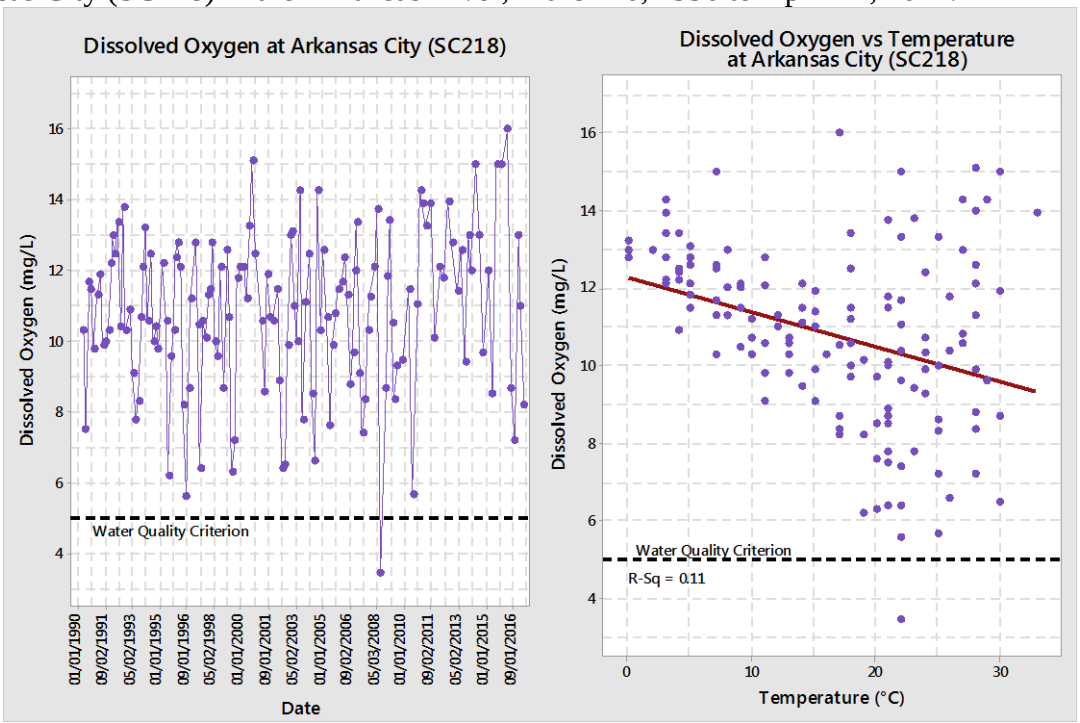


Table 9. Mean dissolved oxygen, dissolved oxygen saturation, and temperature, as well as median pH, by season (spring: April through June, summer-fall: July through October, winter: November through March) in the Little Arkansas and Arkansas River, March 20, 1990 to April 24, 2017.

Station	Spring	Summer-Fall	Winter	All Seasons
Temperature (°C)				
Little Arkansas River at Wichita (SC728)	20.50	21.77	7.24	15.40
Arkansas River at Wichita (SC729)	22.00	24.19	8.37	17.02
Arkansas River at Derby (SC281)	19.81	23.17	7.25	15.61
Arkansas River at Oxford (SC527)	20.57	23.13	7.60	16.00
Arkansas River near Arkansas City (SC218)	20.81	23.64	8.15	16.40
Dissolved Oxygen (mg/L)				
Little Arkansas River at Wichita (SC728)	7.84	7.52	11.66	9.32
Arkansas River at Wichita (SC729)	9.00	9.42	13.04	10.82
Arkansas River at Derby (SC281)	8.34	8.23	11.50	9.64
Arkansas River at Oxford (SC527)	8.81	9.18	11.69	10.13
Arkansas River near Arkansas City (SC218)	9.51	10.54	11.87	10.83
Dissolved Oxygen Saturation (%)				
Little Arkansas River at Wichita (SC728)	86.7	84.3	95.6	89.6
Arkansas River at Wichita (SC729)	102	113	111	109
Arkansas River at Derby (SC281)	89.4	97.4	95.1	94.4
Arkansas River at Oxford (SC527)	98.0	108	97.4	101
Arkansas River near Arkansas City (SC218)	106	125	98.7	109
pH				
Little Arkansas River at Wichita (SC728)	7.7	7.8	7.8	7.8
Arkansas River at Wichita (SC729)	8.0	8.0	8.1	8.0
Arkansas River at Derby (SC281)	7.9	7.9	8.0	8.0
Arkansas River at Oxford (SC527)	8.2	8.2	8.1	8.2
Arkansas River near Arkansas City (SC218)	8.3	8.5	8.2	8.3

Primary productivity increases in the spring and summer-fall, when temperatures increase and DO concentrations decrease. When primary productivity is excessive, oxygen from photosynthesis can create DO concentrations that exceed the natural oxygen equilibrium of the water at a given temperature, and the water is considered supersaturated. All stations along the Arkansas River display supersaturated conditions exceeding 110% DO saturation over the period of record (**Figures 56-60**). The Arkansas River stations at Wichita (SC729), Derby (SC281), Oxford (SC527), and Arkansas City (SC218) display frequent DO saturation excursions, with excursions at Derby (SC281) and Oxford (SC527) increasing since 2000. The station with the most consistent excursions and the highest mean DO saturation is Arkansas City (SC218), with a summer-fall value of 125% (**Table 9**).

Figure 56. Dissolved oxygen saturation and the relationship between dissolved oxygen saturation and temperature at Wichita (SC728) in the Little Arkansas River, June 20, 2000 to April 18, 2017.

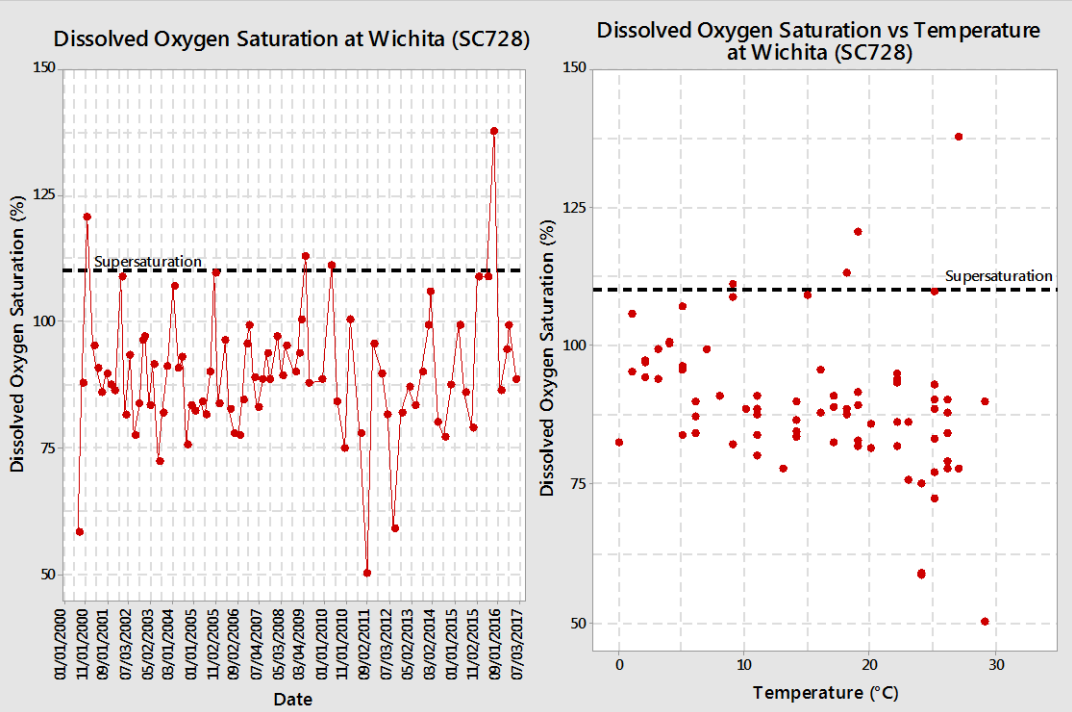


Figure 57. Dissolved oxygen saturation and the relationship between dissolved oxygen saturation and temperature at Wichita (SC729) in the Arkansas River, June 20, 2000 to April 24, 2017.

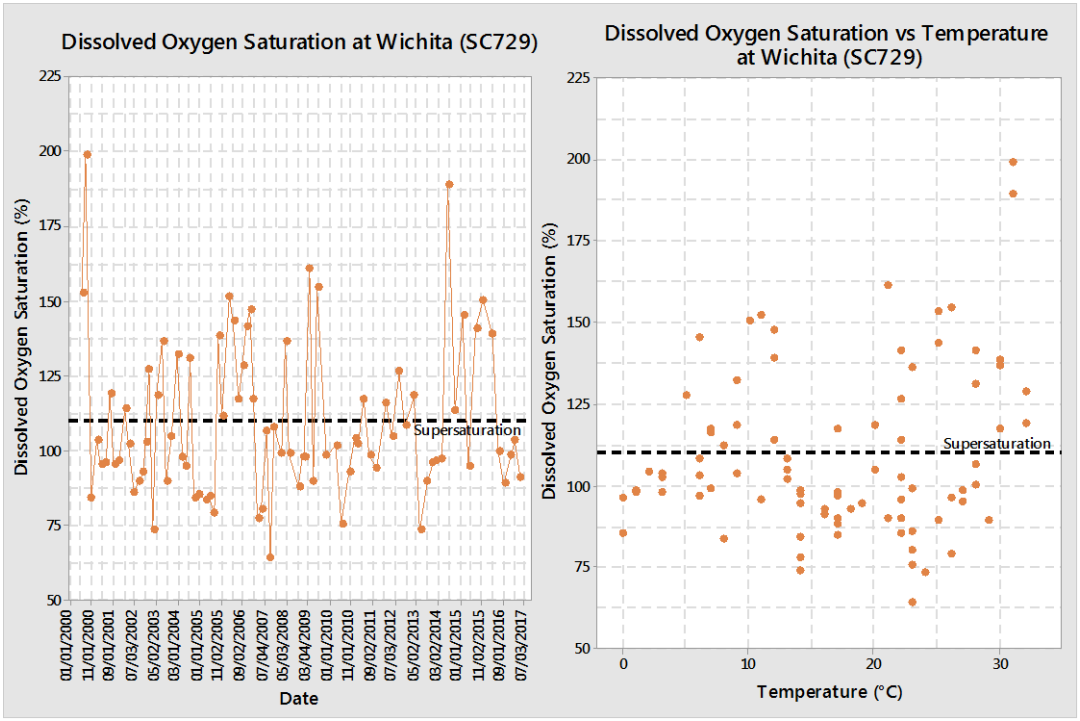


Figure 58. Dissolved oxygen saturation and the relationship between dissolved oxygen saturation and temperature at Derby (SC281) in the Arkansas River, March 20, 1990 to April 24, 2017.

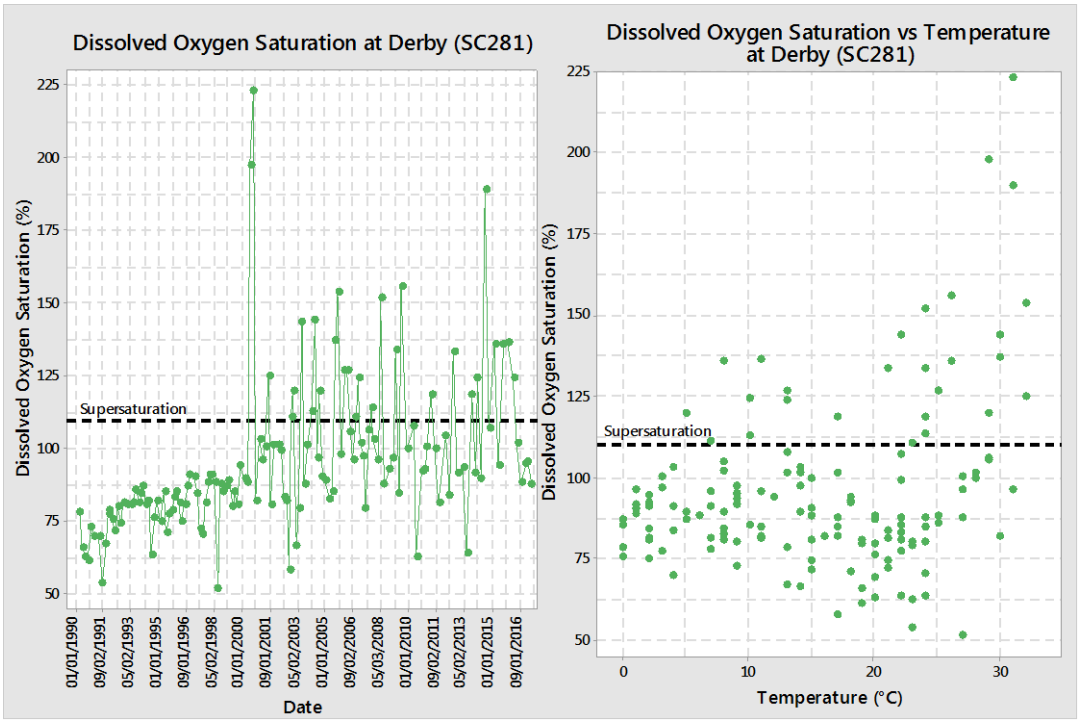


Figure 59. Dissolved oxygen saturation and the relationship between dissolved oxygen saturation and temperature at Oxford (SC527) in the Arkansas River, March 20, 1990 to April 24, 2017.

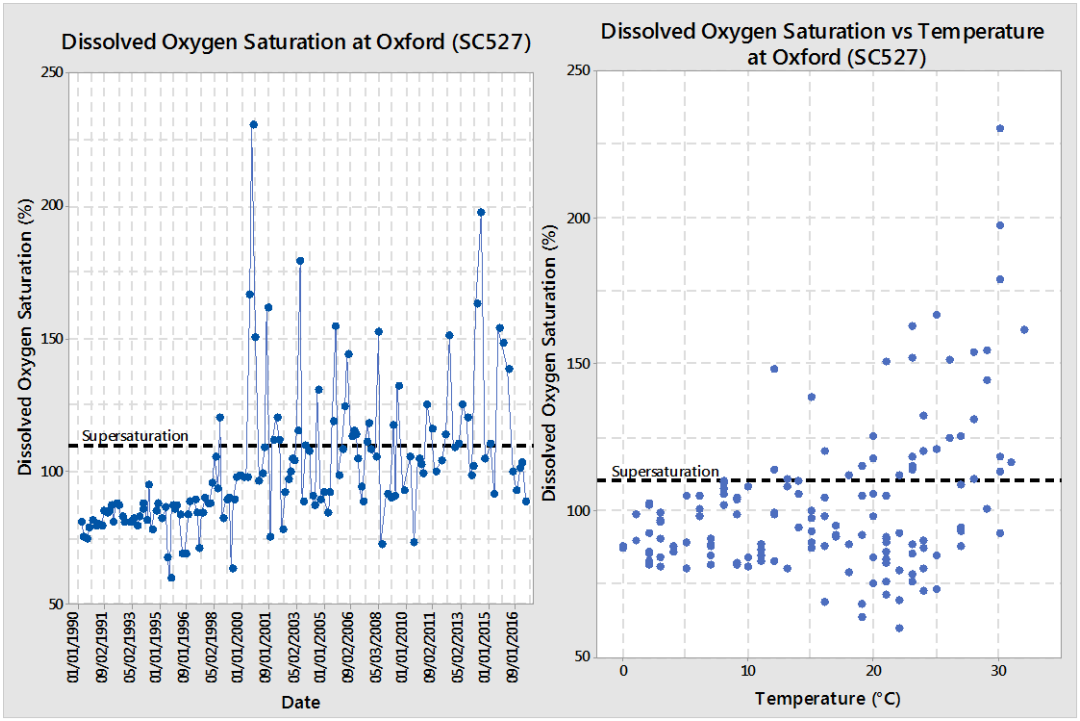
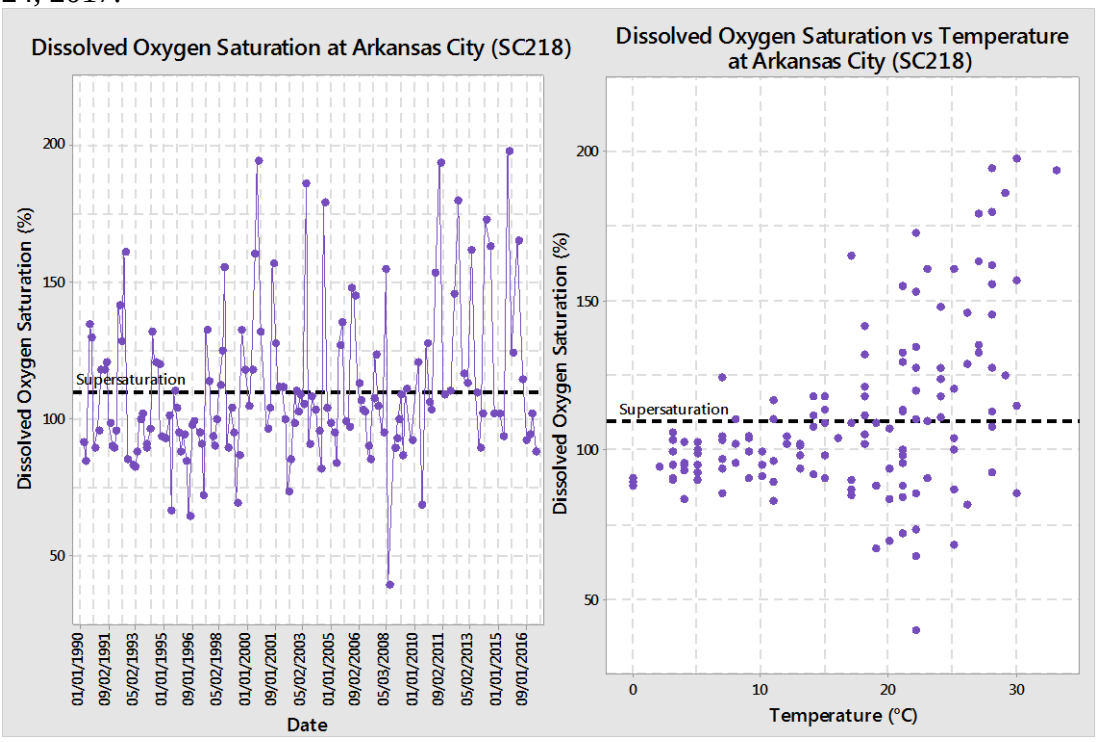


Figure 60. Dissolved oxygen saturation and the relationship between dissolved oxygen saturation and temperature at Arkansas City (SC218) in the Arkansas River, March 20, 1990 to April 24, 2017.



Another water quality indicator of primary productivity is pH, as photosynthesis can increase pH by removing carbon dioxide from the water. The numeric water quality criteria for pH is a range of 6.5 to 8.5; with the exception of the Little Arkansas River at Wichita (SC728; **Figure 61**), which has never had an excursion, the criteria of 8.5 is predominantly exceeded at all sites when temperatures increase (**Figures 62-65**). There have been six excursions at Arkansas River at Wichita (SC729) and Derby (SC281); however the most frequent excursions occur at Oxford (SC527) and Arkansas City (SC218), with 17 and 36 excursions, respectively. The latter two stations have consistently exceeded the water quality criteria of 8.5 throughout the period of record. Despite these excursions, median pH remains relatively consistent at all stations, ranging from 7.7 to 8.3 (**Table 9**); however, there is a noticeable and consistent increase in median pH values across all seasons from the upstream Derby (SC281; spring: 7.9, summer-fall: 7.9, winter: 8.0) to the downstream Arkansas City (SC218; spring: 8.3, summer-fall: 8.5, winter: 8.2).

Figure 61. The pH and the relationship between pH and temperature by season at Wichita (SC728) in the Little Arkansas River, June 20, 2000 to April 18, 2017.

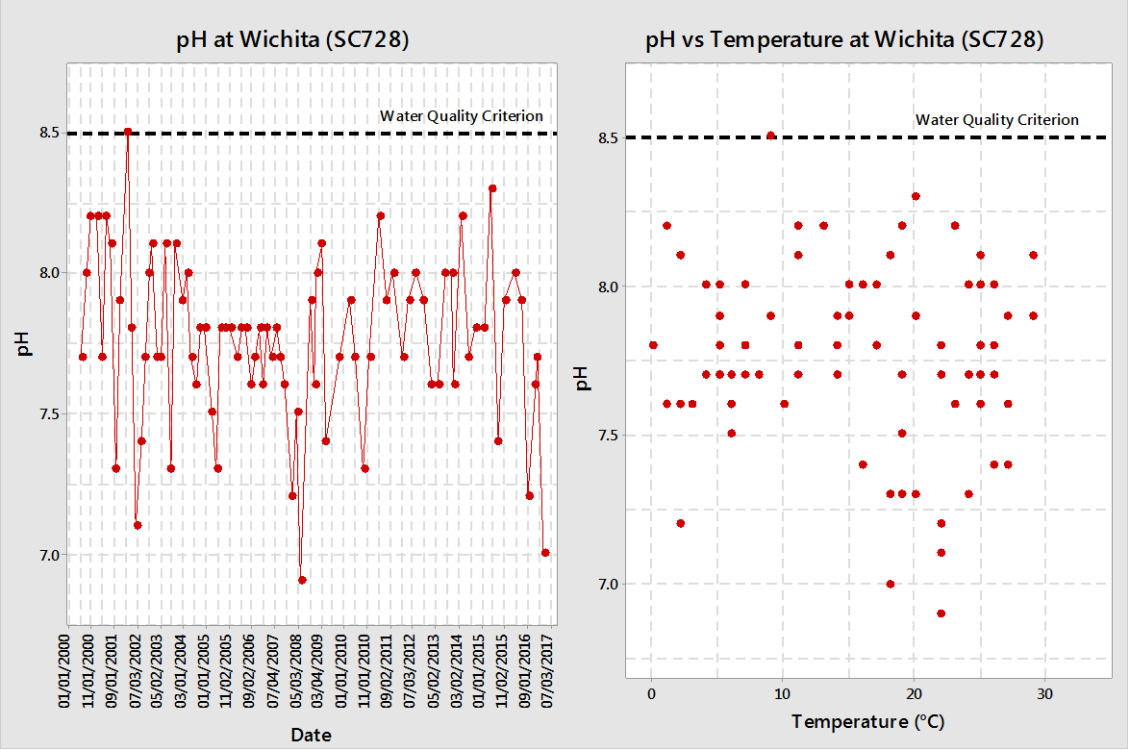


Figure 62. The pH and the relationship between pH and temperature by season at Wichita (SC729) in the Arkansas River, June 20, 2000 to April 24, 2017.

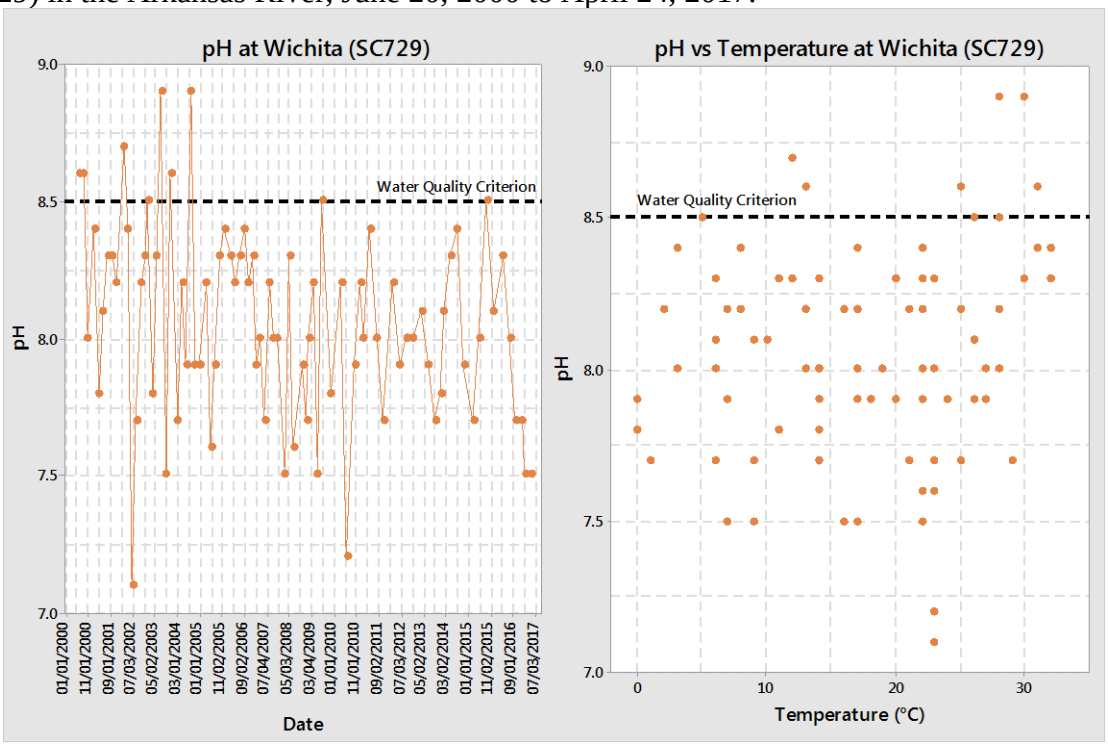


Figure 63. The pH and the relationship between pH and temperature by season at Derby (SC281) in the Arkansas River, March 20, 1990 to April 24, 2017.

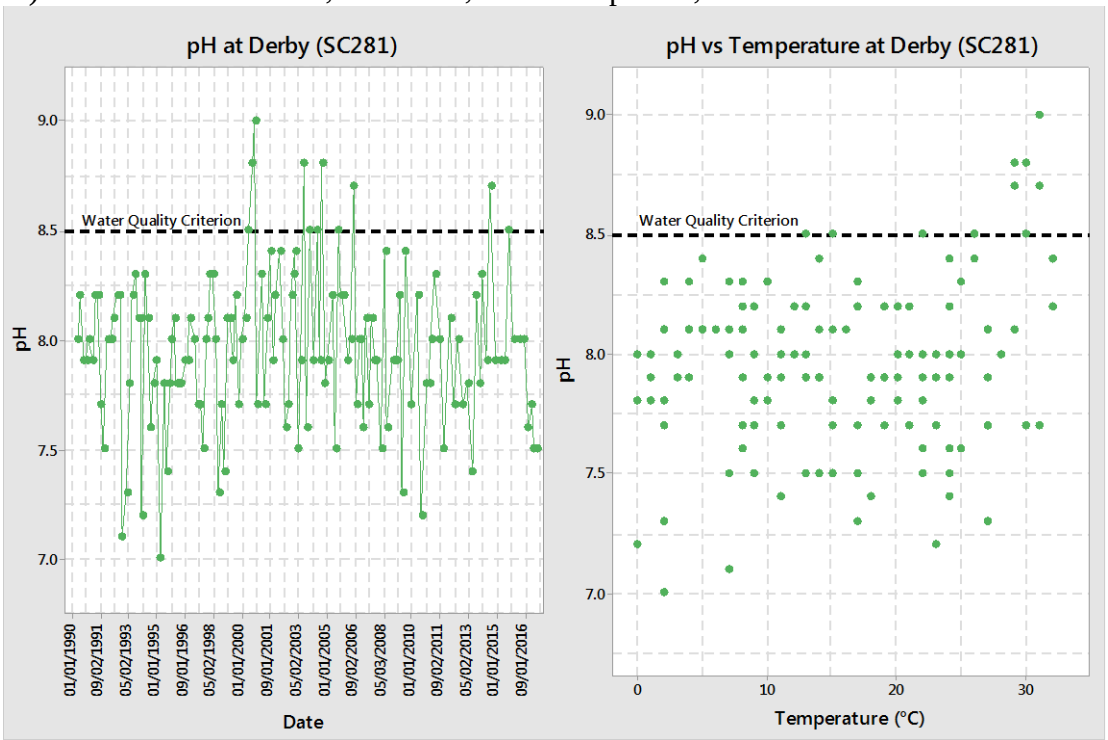


Figure 64. The pH and the relationship between pH and temperature by season at Oxford (SC527) in the Arkansas River, March 20, 1990 to April 24, 2017.

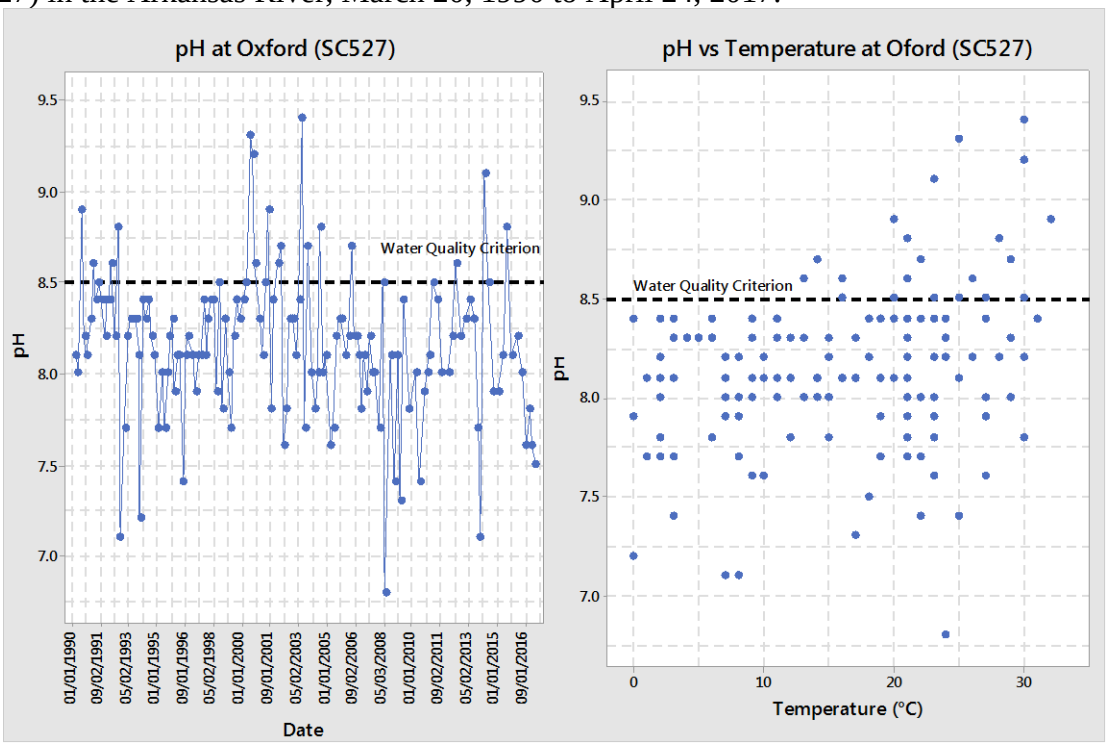
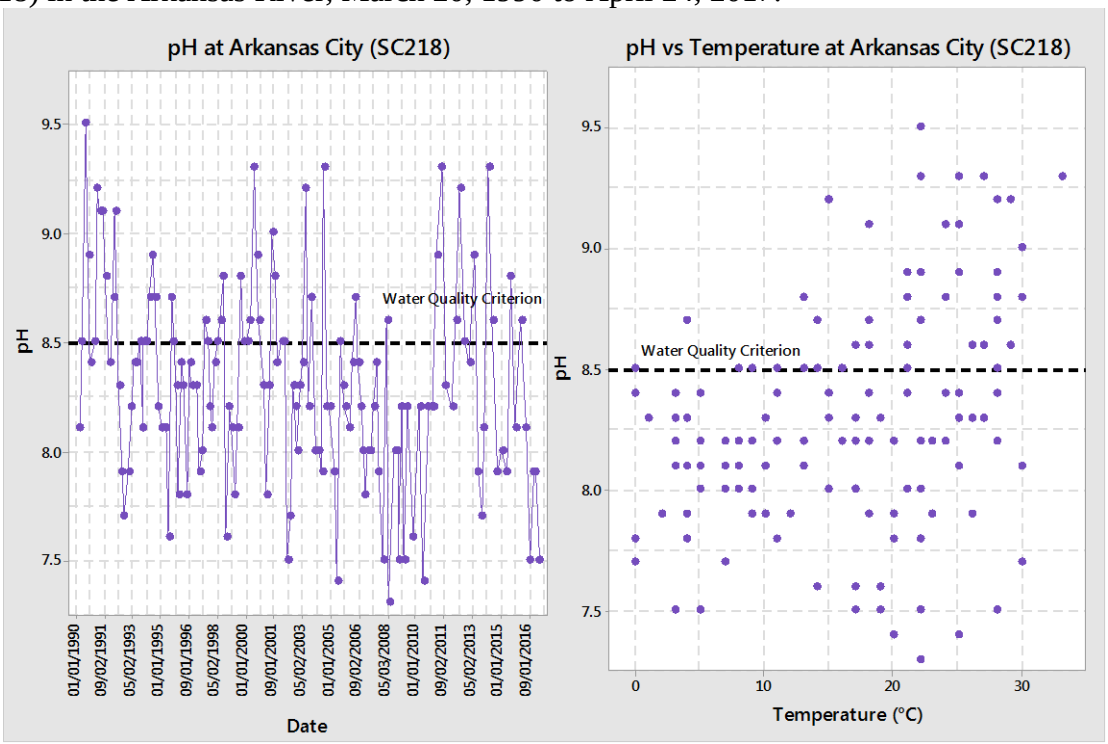


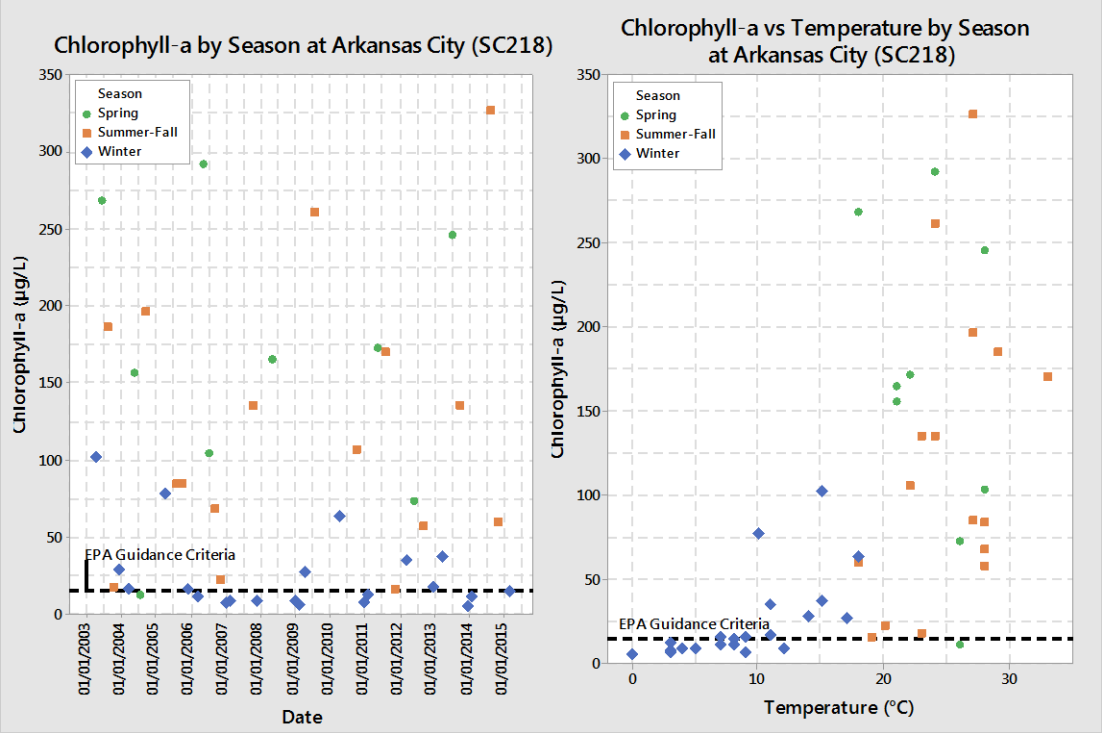
Figure 65. The pH and the relationship between pH and temperature by season at Arkansas City (SC218) in the Arkansas River, March 20, 1990 to April 24, 2017.



Chlorophyll-*a* is a photosynthetic pigment found in algae, and its concentration is commonly used as a measure of the algal biomass present in streams. Chlorophyll-*a* data is collected by KDHE at Arkansas City (SC218). Interpretation of chlorophyll-*a* data must be qualified by the following: sample station is heavily influenced by industrial WWTP effluent and therefore may not be representative of other stations; samples collected form a comparatively small sample set in relation to other parameters; and sample collection is based upon visual confirmation of the presence of algae, creating a bias towards high chlorophyll-*a* concentrations in the data set. Because of these factors, chlorophyll-a data must be interpreted with caution.

Data is available from 2003 to 2015 (**Figure 66**), and concentrations at Arkansas City (SC218) range from 5.45 to 326 µg/L with a mean of 85.5 µg/L and a median of 58.6 µg/L. Because nutrients directly influence primary production, the U.S. Environmental Protection Agency guidance on nutrient criteria for streams establishes a chlorophyll-*a* concentration range of 8-15 µg/L before overall biology can become adversly impacted (U.S. Environmental Protection Agency, 2000). This criteria is exceeded during all seasons at Arkansas City (SC218).

Figure 66. Chlorophyll-*a* and the relationship between chlorophyll-*a* and temperature by season at Arkansas City (SC218) in the Arkansas River, March 18, 2003 to February 17, 2015.



Throughout all seasons, chlorophyll-*a* concentrations increase as temperatures increase (**Figure 66**). Higher chlorophyll-*a* concentrations occur at lower (8-10 mg/L) DO concentrations during the spring and summer-fall, which is an expected trend for seasons with warmer temperatures; however, higher chlorophyll-*a* concentrations also occur at higher (12-14 mg/L) DO concentrations in the spring and summer-fall, indicating that excessive primary productivity may have increased DO concentrations (**Figure 67**). Supersaturated conditions for DO saturation occur in the spring and summer-fall and coincide with higher chlorophyll-*a* concentrations, with

120 to 170% DO saturation exhibiting chlorophyll-*a* concentrations ranging from 57 to 326 µg/L. Elevated pH values occur in the spring and summer-fall and coincide with higher chlorophyll-*a* concentrations, as well (**Figure 68**). Chlorophyll-*a* concentrations vary across the range of TP concentrations, with winter chlorophyll-*a* values rarely exceeding 50 µg/L. Spring and summer-fall chlorophyll-*a* concentrations range from 58 to 326 µg/L across the same range of TP concentrations, highlighting the seasonal component that is integral to driving TP uptake by primary producers.

Understanding the activity of primary producers and their interaction with and affect upon water quality is imperitive to interpreting the biological health of a stream. Specifically, and as previously mentioned, primary productivity can alter ambient levels of oxygen and the acid-base balance in the stream through photosynthesis and respiration, resulting in shifts in the biological commnunity within the stream.

Figure 67. Relationship between chlorophyll-*a* and dissolved oxygen and dissolved oxygen saturation by season at Arkansas City (SC218) in the Arkansas River, March 18, 2003 to February 17, 2015.

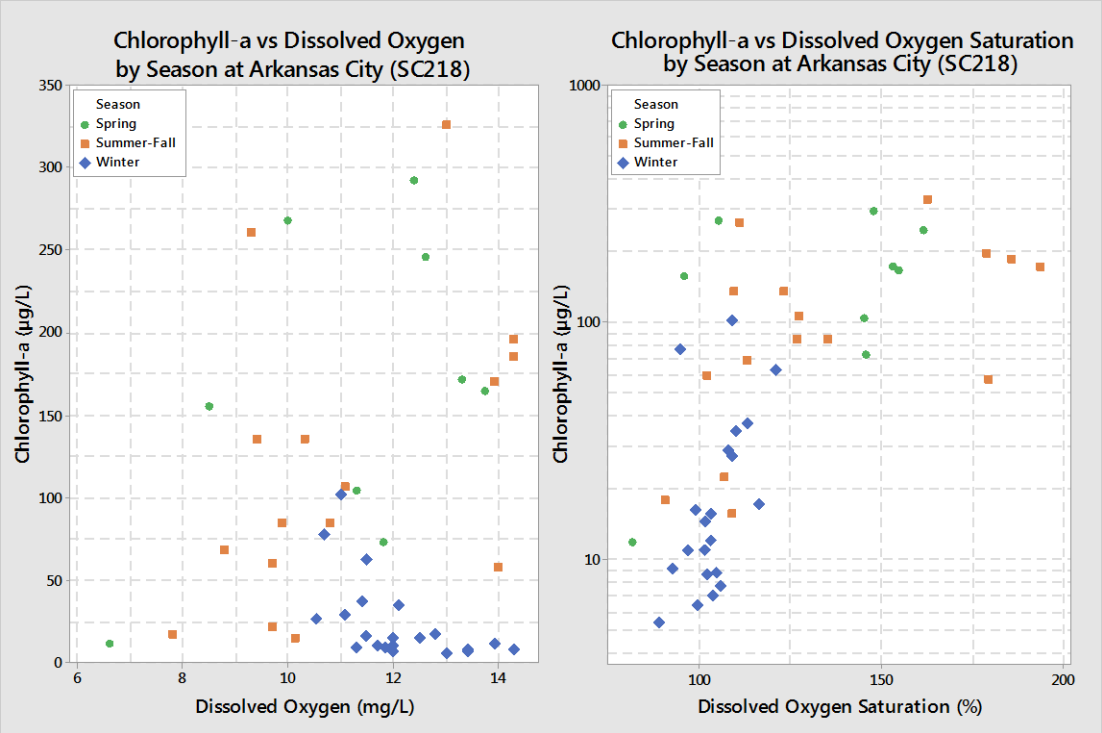
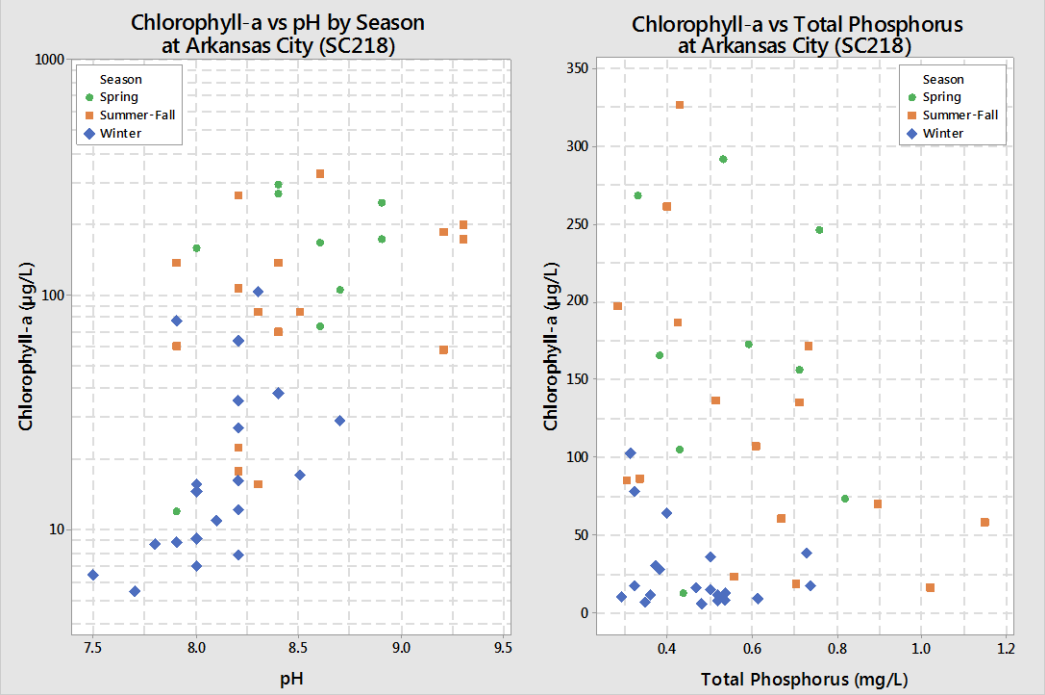


Figure 68. Relationship between chlorophyll-*a* and pH and total phosphorus by season at Arkansas City (SC218) in the Arkansas River, March 18, 2003 to February 17, 2015.



Data regarding macroinvertebrate organisms and community are collected at KDHE stream biology (SB) stations. Sampled SB stations include the Little Arkansas River at Wichita (SB728) and the Arkansas River at Derby (SB281) and Arkansas City (SB218). The SB stations have been assessed using the Aquatic Life Support (ALUS) Index as described in Kansas' 2016 303(d) Methodology. The ALUS Index score consists of five categorizations of biotic conditions:

1. Macroinvertebrate Biotic Index (MBI): A statistical measure that evaluates the effects of nutrients and oxygen demanding substances on macroinvertebrates based on the relative abundance of certain indicator taxa (orders and families).
2. Kansas Biotic Index for Nutrients (KBI-N): A statistical measure mathematically equivalent to the MBI; however, the tolerance values are species specific and restricted to aquatic insect orders.
3. Ephemeroptera, Plecoptera, and Trichoptera (EPT): Abundance as a percentage of the total abundance of macroinvertebrates.
4. EPT Percent of Count (EPT % CNT): The percentage of organisms in a sample consisting of individuals belonging to the EPT orders.
5. Shannon's Evenness (SHN EVN): A measure of diversity that describes how evenly distributed the numbers of individuals are among the taxa in a sample.

These metrics are used to establish a score (**Table 10**) which is then translated into an indication of the biotic condition and life support category available in the stream (**Table 11**).

Table 10. Aquatic Life Use Support Index metrics with scoring ranges and standardized scores (Kansas Department of Health and Environment, 2016).

MBI	KBI-N	EPT	EPT% CNT	SHN EVN	Score
≤ 4.18	≤ 2.52	≥ 16	≥ 65	≥ 0.849	4
4.19-4.38	2.53-2.64	14-15	56-64	0.826-0.848	3
4.39-4.57	2.65-2.75	12-13	48-55	0.802-0.825	2
4.58-4.88	2.76-2.87	10-11	38-47	0.767-0.801	1
≥ 4.89	≥ 2.88	≤ 9	≤ 37	≤ 0.766	0

Table 11. Aquatic Life Use Support (ALUS) Index score range, interpretation of biotic condition, and explanation of support (Kansas Department of Health and Environment, 2016).

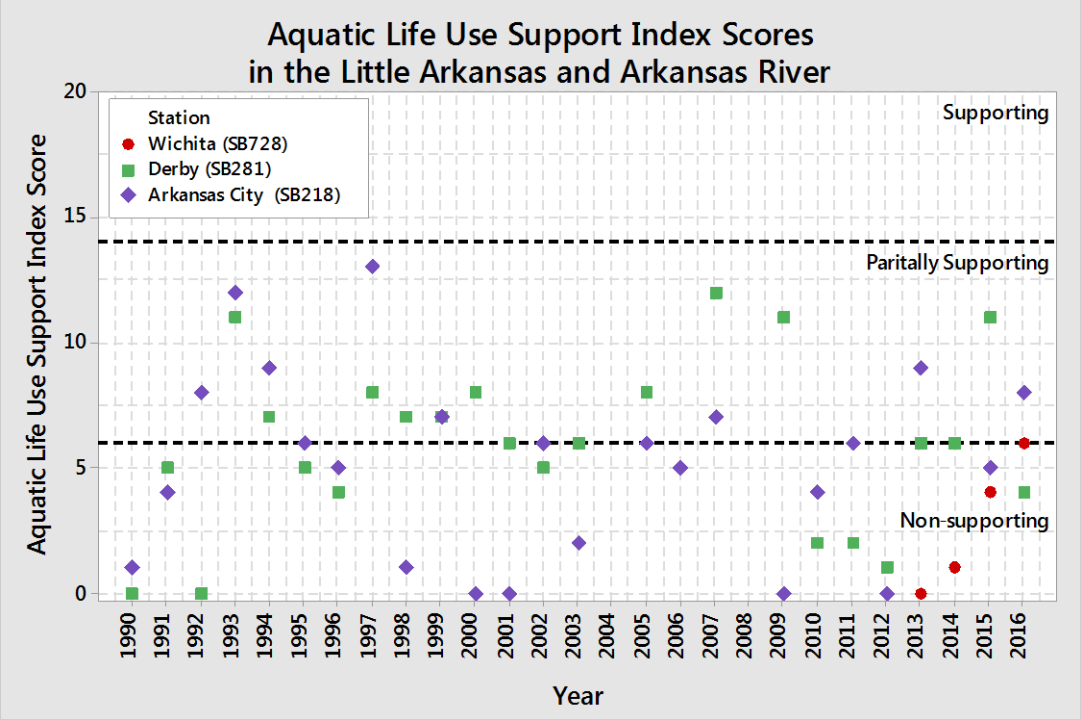
ALUS Index Score	Biotic Condition	Support Category
>16-20	Very Good	Supporting
>13-16	Good	
>7-13	Fair	Partially Supporting
>4-6	Poor	Non-supporting
0-3	Very Poor	

Biotic conditions were sampled annually in the Little Arkansas River at Wichita (SB728) from 2013 to 2016, in the Arkansas River at Derby (SB281) from 1990 to 2016 (except for 2004, 2006, and 2008), and in the Arkansas River at Arkansas City (SB218) from 1990 to 2016 (except for 2004, 2008, and 2014; **Table 12**). The station in the Little Arkansas River at Wichita (SB728) has a total of four samples with a mean ALUS Index score of 3, indicating biotic conditions are very poor. The stations in the Arkansas River at Derby (SB281) and Arkansas City (SB218) have a total of 24 samples each with a mean ALUS Index score of 6 and 5, respectively, indicating biotic conditions are poor. All SB stations are classified as non-supporting for aquatic life. None of the three stations has achieved the supporting category throughout the sampled period of record (**Figure 69**).

Table 12. Mean Aquatic Life Use Support (ALUS) Index scores in the Little Arkansas and Arkansas River.

Station	Period of Record	Number of Samples	Mean ALUS Index Score	Biotic Condition	ALUS Index Support Category
Little Arkansas River at Wichita (SB728)	July 2, 2013 to Oct. 12, 2016	4	3	Very Poor	Non-Supporting
Arkansas River at Derby (SC281)	May 3, 1990 to Oct. 20, 2016	24	6	Poor	Non-Supporting
Arkansas River at Arkansas City (SB218)	May 2, 1990 to Oct. 19, 2016	24	5	Poor	Non-Supporting

Figure 69. Aquatic Life Use Support Index scores in the Arkansas River at Wichita (SB728) and the Arkansas River at Derby (SB281) and Arkansas City (SB218).



Desired Endpoints of Water Quality (Implied Load Capacity) in the Little Arkansas River from Valley Center to Wichita and in the Arkansas River from Wichita to the terminus of segment 110300131, below Arkansas City.

The ultimate endpoint of this TMDL will be to achieve the Kansas Water Quality Standards by eliminating the impacts to aquatic life, domestic water supply, and recreation associated with excessive phosphorus and objectionable flora as described in the narrative criteria pertaining to nutrients. There are no existing numeric phosphorus criteria currently in Kansas. The U.S. EPA suggested benchmark for stream TP in the South Central Cultivated Great Plains Nutrient Ecoregion V is 0.067 mg/L over the ten-state aggregate of Level III ecoregions.

The Little Arkansas River and Arkansas River watersheds included in this document lie within U.S. EPA Level IV Ecoregion of the Central Great Plains (27). Assessment of TP data from the 129 KDHE monitoring stations located in the Central Great Plains ecoregion for the 1990 through 2016 period of record was used to establish TP milestones for the TMDLs included in this document (**Table 13**).

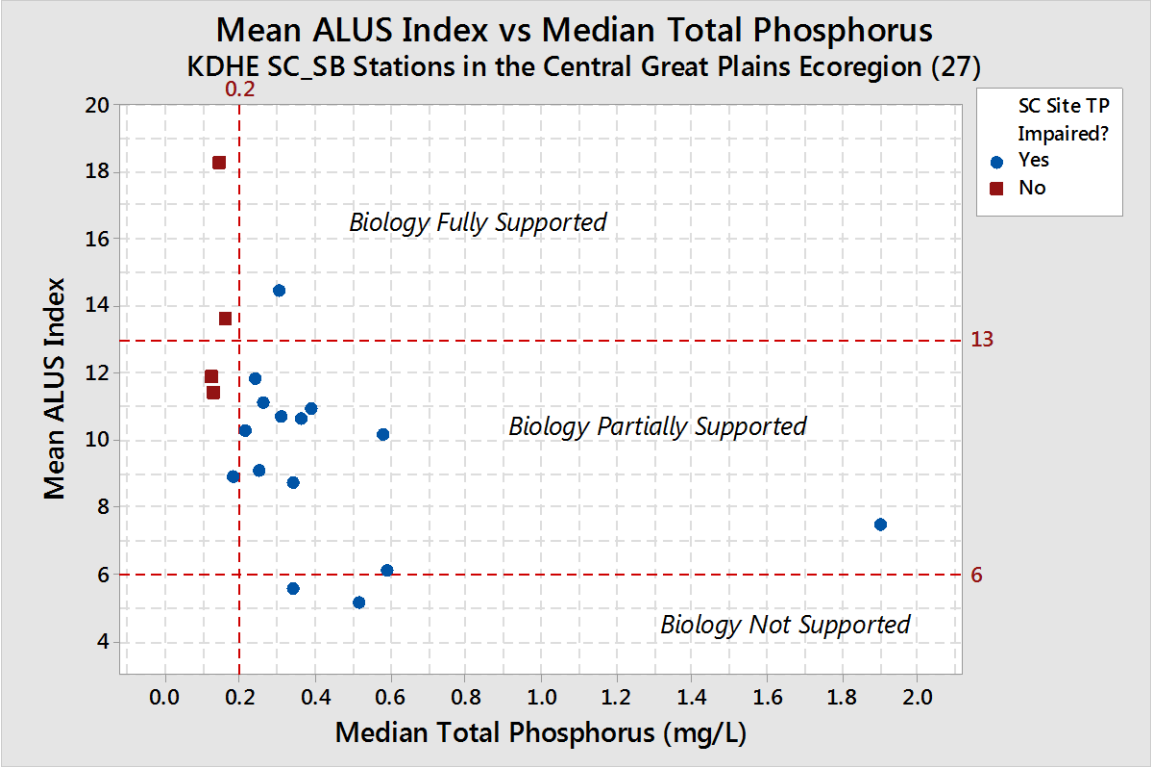
Table 13. Summary data of Kansas Department of Health and Environment (KDHE) stream chemistry stations located in US EPA Level III Ecoregion of the Central Great Plains (27) for the 2000 through April 2018 period of record.

US EPA Level III Ecoregion	Number of KDHE Stations	Number of Samples	Q1 of Station Medians (mg/L)	Median of Station Medians (mg/L)	Q3 of Station Medians (mg/L)
Central Great Plains (27)	129	7,248	0.130	0.200	0.374

Current EPA nutrient philosophy is predicated on the lowest quartile of stream total phosphorus within an ecoregion as indicative of minimal impact conditions. This generalization is not tied to specific biological conditions but represents water quality protection policy guiding EPA's administration of clean water programs.

Figure 70 displays the relationship between median phosphorus values and ALUS Index score within the Central Great Plains (27) Ecoregion. Higher ALUS Index scores are indicative of higher quality biological communities. There are 19 KDHE monitoring stations located in the Central Great Plains Ecoregion that have corresponding biology and TP datasets over the 1990 through 2016 period of record. When median TP concentrations are compared to the mean ALUS Index for those stations, the resulting plot reveals three stations fully supporting biology with median TP values ranging from 0.140 to 0.300 mg/L while stations partially supporting biology have TP concentrations ranging from to 0.180 to 1.90 mg/L. The three stations in the ecoregion currently unimpaired for TP have a mean ALUS Index of 15.4; meanwhile, the impaired stations on the 303(d) list for TP demonstrate less support for biology with a mean ALUS Index of 9.4.

Figure 70. Median total phosphorus (TP) versus mean Aquatic Life Use Score (ALUS) Index for stream chemistry/stream biology (SC/SB) stations located in Kansas' Central Great Plain Ecoregion (27) from 1990 through 2016.



The greatest complication in setting an endpoint is establishing the linkage of phosphorus levels to applicable biologic response variables. Displayed in **Figure 70** is a noisy relationship between the ALUS Index and phosphorus that defies establishing a solitary threshold value and supports an adaptive management approach to reduce current phosphorus loads and concentrations; this adaptive management approach requires observing and responding to improvement in biological metrics and sestonic chlorophyll-*a* prior to further reductions. Therefore, the primary measure of reduction in nutrient loading to the impaired segments in the TMDL watershed will be the ALUS Index. The ALUS Index will serve to establish if the biological community at the SC stations in the watershed reflect recovered, renewed diversity and minimal disruption by the impacts described in the narrative criteria for nutrients on aquatic life, recreation, and domestic water supply.

Additionally, the concentration of suspended sestonic phytoplankton in the water column at KDHE SC stations will indicate if primary productivity has moderated to reduce the impacts described in the narrative criteria for nutrients on aquatic life, recreation, and domestic water supply.

Secondary indicators of the health of the instream biological community include:

1. Dissolved oxygen concentrations greater than 5.0 mg/L and the dissolved oxygen saturation not more than 110%. Dissolved oxygen saturation is the measure of oxygen in the water relative to the water's potential dissolved oxygen concentration.

Dissolved oxygen concentrations below 5.0 mg/L put aquatic life under stress while dissolved oxygen saturation percentages greater than 110% are indicative of over-active primary productivity.

2. Instream pH values remain below 8.5. Excessive nutrients can induce vigorous photosynthesis which will cause pH to rise above 8.5, the current Kansas water quality criterion.

Therefore, the numeric endpoints for stream segments included in this TMDL, as measured at Little Arkansas River at Wichita (SC728/SB728) and Arkansas River at Wichita (SC729), Derby (SC281/SB281), Oxford (SC527), and Arkansas City (SC218/SB281), indicating attainment of water quality standards within the watershed are:

1. An ALUS Index score greater than or equal to 13 at SB stations.
2. Median sestonic chlorophyll-*a* concentrations less than or equal to 10 µg/L at SC stations.
3. Dissolved oxygen concentrations greater than 5.0 mg/L at SC stations.
4. Dissolved oxygen saturation less than 110% at SC stations.
5. Values within the range of 6.5 to 8.5 for pH at SC stations.

All five endpoints have to be initially maintained over three consecutive years to constitute full support of the designated uses of the impaired stream segments included in the TMDL watershed, as measured at KDHE stations Little Arkansas River at Wichita (SC728/SB728) and Arkansas River at Wichita (SC729), Derby (SC281/SB281), Oxford (SC527), and Arkansas City (SC218/SB281). After the endpoints are attained, simultaneous digression of these endpoints more than once every three years, on average, constitutes a resumption of the TP impairment at the respective station unless the TP impairment is delisted through the 303(d) process.

There are no existing numeric phosphorus criteria currently in Kansas. Hence, the series of endpoints established by this TMDL will be the measure used to indicate full support of aquatic life, domestic water supply, and recreation uses in the Little Arkansas and Arkansas Rivers. These endpoints will be evaluated periodically as phosphorus levels decline in the watershed, with achievement of the ALUS Index endpoint indicating the restored status of the aquatic life use in the river.

This TMDL seeks to establish phased TP milestones derived from the central tendency of concentrations within the Kansas Central Great Plains Ecoregion which will cue the examination for altered, improved biological conditions in the river (**Table 14**). Once TP concentrations at KDHE SC stations approach the Phase I management milestones, assessment of the biological community in the river will be initiated at KDHE SB stations. Should the biological community fail to respond to the Phase I reduction of TP, Phase II will commence. Simultaneous achievement of the chlorophyll-*a*, dissolved oxygen, dissolved oxygen saturation, and pH endpoints will signal phosphorus reductions are addressing the accelerated succession of aquatic biota and the development of objectionable concentrations of algae and algae by-products, thereby restoring the domestic water supply and contact recreation uses in the river.

Table 14. Total phosphorus (TP) current condition from 2000 through April 2017 and Phase I and Phase II TP milestones for the Little Arkansas River and Arkansas River watersheds.

Stream Chemistry Station	Current Condition	TMDL Phase I		TMDL Phase II	
	Median TP (mg/L)	TP Milestone (mg/L)	Reduction in TP from Current Condition	TP Milestone (mg/L)	Reduction in TP from Current Condition
Little Arkansas R at Wichita (SC728)	0.409	0.374	9%	0.130	68%
Arkansas R at Wichita (SC729)	0.237	0.200	16%	0.130	45%
Arkansas R at Derby (SC281)	0.649	0.374	42%	0.130	80%
Arkansas R at Oxford (SC527)	0.432	0.374	13%	0.130	70%
Arkansas R at Arkansas City (SC218)	0.547	0.374	32%	0.130	76%

Additionally, reductions in TP loading will reduce the degree of primary productivity occurring in the river as determined by chlorophyll *a* concentrations measuring below 10 µg/L. Exceedances of the pH criterion of 8.5 can occur because of excessive primary productivity, particularly during the summer months. During photosynthesis, carbon dioxide and water are converted to sugar, oxygen, and hydroxyl ions leading to increased pH levels. The target of 10 µg/L chlorophyll *a* should indicate primary productivity is under control and pH exceedances, particularly during the summer months should abate. Achievement of the pH endpoint in the river at Oxford (SC527) and Arkansas City (SC218) indicates pH in the river has been restored to a degree that it is now meeting the Kansas Surface Water Quality Standard for pH thereby making the Arkansas River near Oxford (SC527) and Arkansas City (SC218) and their related segments eligible to move to Category 2 status (delisted) during the following 303(d) cycle.

3. SOURCE INVENTORY AND ASSESSMENT

Point Sources: There are a total of 44 National Pollution Discharge Elimination System (NPDES) permitted facilities within the Arkansas River watershed from Wichita to Arkansas City (**Table 15**). This portion of the Arkansas River watershed includes the subwatersheds of Little Arkansas River at Wichita (SC728) and Arkansas River at Wichita (SC729), Derby (SC281), Oxford (SC527), and Arkansas City (SC218). Of the 44 permitted facilities, five are located in the Little Arkansas River at Wichita (SC728) watershed, 19 are located in the Arkansas River at Wichita (SC729) watershed, eight are located in the Derby (SC281) watershed, six are located in the Oxford (SC527) watershed, and six are located in the Arkansas City (SC218) watershed. Additionally, there are 11 Municipal Separate Storm Sewer System (MS4) permits within the Arkansas River watershed from Wichita to Arkansas City.

Table 15. National Pollution Discharge Elimination System (NPDES) facilities and total phosphorus (TP) monitoring in the Arkansas River watershed from Wichita to Arkansas City. Description: N/A - not applicable; ** - not required to monitor total phosphorus as condition of current NPDES permit; * - no data available; $^{+}$ - updated permit in process

Site	Permit #	Permitee	Type	Current Effluent Flow (MGD)	Current Avg. TP (mg/L) in Effluent	TP Monitoring Frequency	Permit Expires	Receiving Stream
SC728	C-LA16-NO01	Country Acres Trailer Court	Non-discharging Lagoon	n/a	n/a	n/a	11/30/20	n/a
SC728	C-LA16-NO03	North Star RV Park & Mobile Home Community	Non-discharging Lagoon	n/a	n/a	n/a	10/31/20	n/a
SC728	P-LA19-OO02	Kice Industries, Inc.	Industrial Pretreatment	*	*	**	12/31/20	POTW
SC728	M-LA19-OO02	Chisholm Creek Utility Authority	Municipal Mechanical WWTP	1.4	0.67	Weekly	11/30/20	Chisholm Creek
SC728	M-LA16-OO02	City of Valley Center	Municipal Mechanical WWTP	0.39	1.11	Monthly	10/31/20	Little Arkansas River
SC729	I-AR94-PR09	Andale Ready Mix	Ready Mix Plant	*	*	**	9/30/22	Chisholm Creek
SC729	I-AR94-PR16	CMC Plant 1 - South Madison Plant	Ready Mix Plant	*	*	**	9/30/22	Arkansas River
SC729	I-AR94-PR10	VMC	Ready Mix Plant	*	*	**	9/30/22	Chisholm Creek
SC729	I-AR94-PR12	Wichita Concrete Pipe Company	Ready Mix Plant	*	*	**	9/30/22	Chisholm Creek
SC729	I-AR94-CO47	Friends University	Industrial Non-contact Cooling	*	*	**	12/31/22	Arkansas River
SC729	I-AR94-PO08	Hospitality Real Estate Corporation	Industrial Non-contact Cooling	*	*	**	11/30/22	Arkansas River
SC729	I-AR94-PO19	Lubrication Engineers	Industrial Non-contact Cooling	*	*	**	11/30/19	Arkansas River via Alluvial Aquifer

Site	Permit #	Permitee	Type	Current Effluent Flow (MGD)	Current Avg. TP (mg/L) in Effluent	TP Monitoring Frequency	Permit Expires	Receiving Stream
SC729	I-AR94-CO10	The Coleman Company, Inc. - Northeast Plant	Industrial Non-contact Cooling	*	*	**	12/31/17+	Chisholm Creek
SC729	I-AR94-PO46	Boeing Wichita - Groundwater Remediation Project	Groundwater Remediation	0.23	*	**	12/31/18	Arkansas River
SC729	I-AR94-PO78	El Paso Merchant Energy	Groundwater Remediation	0.30	*	**	12/31/18	East Fork Chisholm Creek
SC729	I-AR94-PO06	Koch-Glitsch Groundwater Remediation	Groundwater Remediation	0.02	*	**	8/31/19	East Fork Chisholm Creek
SC729	I-AR94-PO80	Gilbert & Mosley Remediation Site	Groundwater Remediation	0.92	0.34	**	5/31/19	Arkansas River
SC729	I-AR94-PO21	New Coleman Holdings, Inc.	Groundwater Remediation	0.28	0.22	Quarterly	7/31/18	Chisholm Creek
SC729	I-AR94-PO76	The Coleman Company, Inc. - Factories A and B	Groundwater Remediation	0.003	0.5	Monthly	12/31/17+	Arkansas River
SC729	I-AR94-PO70	The Coleman Company, Inc. - Northeast Groundwater Remediation	Groundwater Remediation	0.14	0.29	Monthly	11/30/22	Chisholm Creek
SC729	I-AR94-PO12	Union Pacific Railroad Hydraulic Containment System	Groundwater Remediation	0.0013	0.28	Annually	3/31/19	East Fork Chisholm Creek
SC729	I-AR94-PO04	Beechcraft Corporation	Industrial Non-Contact Cooling & Groundwater Remediation	0.042	0.05	Quarterly	12/31/18	Gypsum Creek

Site	Permit #	Permitee	Type	Current Effluent Flow (MGD)	Current Avg. TP (mg/L) in Effluent	TP Monitoring Frequency	Permit Expires	Receiving Stream
SC729	I-AR94-PO05	Cessna Aircraft Company - Pawnee Facility	Industrial Non-Contact Cooling & Groundwater Remediation	0.18	0.28	Annually	1/31/17+	Gypsum Creek
SC729	I-AR94-PO20	Spirit Aerosystems, Inc	Industrial Mechanical Waste Treatment	0.006	*	**	12/31/13+	Arkansas River
SC281	C-AR94-NO21	The Mann Cave	Non-discharging Lagoon	n/a	n/a	n/a	11/30/18	N/A
SC281	I-AR94-PR07	CMC - West Robbins Plant	Concrete operation	0.0125	*	**	9/30/22	Arkansas River
SC281	I-AR94-CO50	Leading Technology Composites	Industrial Non-contact Cooling	0.02	*	**	12/31/22	Arkansas River
SC281	I-AR94-PO62	Wescon Plastics, LLC	Industrial Non-contact Cooling	0.36	0.19	**	12/31/17+	Arkansas River
SC281	I-AR94-PO90	Air Capital Flight Line, LLC	Groundwater Remediation	0.086	*	**	12/31/13+	Arkansas River
SC281	I-AR94-PO31	Globe Engineering Company	Groundwater Remediation	0.4	*	**	9/30/22	Arkansas River via Wichita Storm Sewer
SC281	F-AR94-PO25	McConnell Air Force Base	Groundwater Remediation	0.001	*	**	4/30/21	Arkansas River
SC281	M-AR94-IO01	City of Wichita - Lower Arkansas River Plant	Municipal Mechanical WWTP	32	4.1	Weekly	11/30/22	Arkansas River
SC527	C-AR29-NO04	Calvary Baptist Church	Non-discharging Lagoon	n/a	n/a	n/a	10/31/18	n/a
SC527	M-AR94-NO05	Fairway Meadows	Non-discharging Lagoon	n/a	n/a	n/a	12/31/18	n/a

Site	Permit #	Permitee	Type	Current Effluent Flow (MGD)	Current Avg. TP (mg/L) in Effluent	TP Monitoring Frequency	Permit Expires	Receiving Stream
SC527	C-AR64-NO01	Prairie Schooner Mobile Home Park	Non-discharging Lagoon	n/a	n/a	n/a	3/31/18	n/a
SC527	C-AR94-OO07	Long Branch Mobile Home Park	Discharging lagoon	*	3.65	Quarterly	6/30/22	Arkansas River
SC527	M-AR29-OO02	City of Derby	Municipal Mechanical WWTP	1.7	2.58	Bimonthly	10/31/22	Arkansas River
SC527	M-AR64-OO02	City of Mulvane	Municipal Mechanical WWTP	0.43	0.27	Monthly	12/31/19	Arkansas River
SC281	C-AR06-NO03	Camp Quaker Haven	Non-discharging Lagoon	n/a	n/a	n/a	8/31/18	N/A
SC281	I-AR06-PO10	City of Arkansas City	Water Treatment Plant	*	*	**	8/31/21	Arkansas River
SC281	M-AR36-OO01	City of Geuda Springs	Discharging lagoon	*	5.48	Quarterly	6/30/22	Salt Creek
SC281	M-AR68-OO01	City of Oxford	Discharging lagoon	*	1.92	Quarterly	6/30/22	Arkansas River
SC281	I-AR06-PO06	Creekstone Farms Premium Beef, LLC	Industrial mechanical WWTP	0.67	23.0	Weekly	12/31/18	Arkansas River
SC281	M-AR06-IO01	City of Arkansas City	Municipal Mechanical WWTP	1.32	4.9	Bimonthly	12/30/22	Arkansas River

Little Arkansas River at Wichita (SC728)

There are a total of five NPDES permitted facilities within the Little Arkansas River at Wichita (SC728) watershed. Of the five permitted facilities, two are non-discharging lagoons, one is an industrial pretreatment facility, and two are municipal mechanical WWTPs.

The two non-discharging lagoons within the watershed are Country Acres Trailer Court and North Star RV Park & Mobile Home Community. Both facilities are two-cell lagoon systems processing domestic waste. Neither of these systems are expected to discharge and contribute TP to the watershed.

The industrial pretreatment facility in the watershed is Kice Industries, Inc. This facility manufactures pneumatic conveyor and filter systems for the grain milling industry and is considered a metal finishing plant. Kice Industries, Inc. is permitted to discharge industrial and domestic waste to the Chisholm Creek Utility Authority WWTP. As such, this facility is not expected to contribute TP to the watershed.

The two municipal mechanical WWTPs within the watershed are operated by the Chisholm Creek Utility Authority and the City of Valley Center. The Chisholm Creek Utility Authority WWTP currently operates at 1.4 MGD. The facility is a cooperative WWTP operated for the City of Park City and the City of Bel Aire. The Chisholm Creek Utility Authority WWTP discharges to Chisholm Creek, which flows into the Little Arkansas River. Previously, the facility monitored monthly for TP from 2003 to 2012. As of 2013, the facility is required to monitor weekly for TP. The discharge from the Chisholm Creek Utility Authority WWTP has a mean TP concentration of 0.67 mg/L. The City of Valley Center WWTP currently operates at 0.39 MGD. The facility is required to monitor monthly for TP and has done so since 2009. The City of Valley Center WWTP is designed for nutrient removal. The discharge to the Little Arkansas River from the City of Valley Center WWTP has a mean TP concentration of 1.11 mg/L. As TP contributors to this watershed, both the Chisholm Creek Utility Authority and the City of Valley Center WWTPs are assigned TP wasteload allocations (WLAs) under this TMDL.

Arkansas River at Wichita (SC729)

There are a total of 19 NPDES permitted facilities within the Arkansas River at Wichita (SC729) watershed. Of the 19 permitted facilities, four are ready-mix concrete operations, four are facilities utilizing industrial non-contact cooling water, eight are facilities implementing groundwater remediation, two are both utilizing industrial non-contact cooling water and implementing groundwater remediation, and one is an industrial mechanical WWTP.

The four ready-mix concrete operations within the watershed are: Andale Ready Mix Central – Wichita, a permanent central mix batch concrete plant; CMC Plant 1 – South Madison Plant, a central mix batch concrete plant with aggregate storage; VMC, a portable concrete batch plant; and Wichita Concrete Pipe Company, a permanent concrete batch plant. All four plants generate wastewater from washing out concrete equipment. Wastewater is retained in concrete or earthen settling basins and clear water is then reused for either on-site dust suppression or concrete production. Domestic waste is discharged to the municipal sewer system or retained in portable toilets. These plants do not monitor for TP and are not expected to contribute TP to the watershed.

The four facilities utilizing industrial non-contact cooling water in the watershed are: Friends University; Hospitality Real Estate Corporation; Lubrication Engineers, Inc.; and The Coleman Company, Inc. – Northeast Plant. Friends University is a college campus using groundwater to cool campus buildings; its primary disposal is an on-site injection well, and its outfall is for emergency discharges. Hospitality Real Estate Corporation is a commercial real estate property using groundwater to cool heat-exchangers. Both facilities add chemicals to their groundwater to sequester contaminants and reduce biofouling prior to use and discharge to the Arkansas River. Lubrication Engineers, Inc. uses groundwater to cool equipment used to blend and package

petroleum-based automotive and industrial lubricants. Groundwater is processed through oil and water separators and an aeration unit prior to discharge into a sandpit that recharges the alluvial aquifer underlying the Arkansas River. The Coleman Company, Inc. – Northeast Plant uses municipal water to cool molding machines for manufacturing outdoor camping equipment. This company discharges to a retention pond that empties into Chisholm Creek. All four facilities use the municipal sewer system for domestic waste. None of these facilities are required to monitor for TP and they are not expected to discharge TP; however, they are assigned a nominal WLA under this TMDL.

There are eight facilities implementing groundwater remediation in the watershed. Three of these facilities are not required to monitor for TP: Boeing Wichita – Groundwater Remediation Project, El Paso Merchant Energy, and Koch-Glitsch Groundwater Remediation. Boeing Wichita – Groundwater Remediation Project is a former aircraft manufacturing facility using air strippers to remediate groundwater. This facility has seven outfalls leading to the Arkansas River and can discharge to the municipal sewer system or Spirit Aerosystem's industrial WWTP, as needed. El Paso Merchant Energy is a former petroleum refinery and asphalt blending operation using aeration and settling tanks to remediate groundwater. This facility removes petroleum products from groundwater and stormwater. Acceptable wastewater is discharged to East Fork Chisholm Creek and all wastewater not meeting permit limits is discharged to the municipal sewer system. Koch-Glitsch Groundwater Remediation uses bag and carbon filters to remediate groundwater from six wells for volatile organic compounds (VOCs). None of these facilities are expected to significantly contribute to the TP impairment and are assigned a nominal WLA under this TMDL.

The five remaining facilities implementing groundwater remediation in the watershed are: Gilbert & Mosley Remediation Site; New Coleman Holdings, Inc.; The Coleman Company, Inc. – Factories A and B; The Coleman Company, Inc. – Northeast Groundwater Remediation; and Union Pacific Railroad Hydraulic Containment System. All of these facilities were either required to monitor for TP in previous permits or are currently required to monitor for TP. Gilbert & Mosley Remediation Site uses an air stripper to remediate groundwater from 13 wells throughout downtown Wichita for VOCs. This facility uses a chemical sequestering agent before discharging to the Arkansas River. It was required to monitor for TP from 2012 to 2014. Based upon this data, Gilbert & Mosley Remediation Site discharges a mean TP concentration of 0.34 mg/L. New Coleman Holdings, Inc. uses an air stripper to remediate groundwater. A pre-treatment chemical to inhibit mineral accumulation is added to groundwater prior to treatment, and treated groundwater is discharged to Chisholm Creek. New Coleman Holdings, Inc. discharges a mean TP concentration of 0.22 mg/L. New Coleman Holdings, Inc. is required to monitor for TP quarterly. The Coleman Company, Inc. – Factories A and B is a previous manufacturing site using an air stripper to remediate groundwater from two wells for VOCs. The Coleman Company, Inc. – Factories A and B discharges a mean TP concentration of 0.5 mg/L to the Arkansas River. The Coleman Company, Inc. – Northeast Groundwater Remediation site uses an air stripper to remediate groundwater from three wells for chlorinated-hydrocarbons. The Coleman Company, Inc. – Northeast Groundwater Remediation site discharges a mean TP concentration of 0.29 mg/L to Chisholm Creek. The latter two Coleman facilities are required to monitor for TP monthly. Union Pacific Railroad Hydraulic Containment System uses bag filters and granular activated carbon to remediate groundwater from six wells for VOCs. Union Pacific

Railroad Hydraulic Containment System monitors annually for TP, discharging a mean TP concentration of 0.28 mg/L to East Fork Chisholm Creek. All five of these facilities are assigned TP WLAs under this TMDL to account for diminutive TP loading associated with the remediated groundwater.

The two facilities utilizing industrial non-contact cooling water and implementing groundwater remediation in the watershed are Beechcraft Corporation and Cessna Aircraft Company – Pawnee Facility. Both facilities manufacture aircrafts and aircraft components. Beechcraft Corporation discharges non-contact cooling water treated with oil and water separators and groundwater treated for halogenated solvents with an air stripper. This facility discharges these waste streams to Gypsum Creek, and all other waste is discharged to the municipal sewer system. Beechcraft Corporation monitors quarterly for TP and discharges a mean TP concentration of 0.05 mg/L. Cessna Aircraft Company – Pawnee Facility uses non-contact cooling water in a spotwelding area and discharges this waste stream to a retention pond. Two groundwater remediation operations occur at this facility, both of which treat VOCs with an air stripper: the discharge from one project commingles with non-contact cooling water discharged to a retention pond; the discharge from the other project is discharged directly to Gypsum Creek and is not monitored for TP. Retention pond flow is discharged to Gypsum Creek, as well, and is monitored annually for TP. Cessna Aircraft Company – Pawnee Facility discharges a mean TP concentration of 0.28 mg/L at the retention pond outfall. To account for TP concentrations observed in the effluent indicating minor TP loading from these facilities, both have been assgined TP WLAs under this TMDL.

The industrial mechanical WWTP in the watershed is Spirit Aerosystems, Inc. This company manufactures and subassembles aircraft components. Before discharge to the Arkansas River via North Lake, the facility treats its main effluent streams for organics, acids, and caustics. This facility is currently in the permit renewal process due to the sale of the company. Spirit Aerosystems, Inc. is not expected to discharge TP and is not required to monitor for TP; however, this facility is assigned a nominal WLA under this TMDL.

Derby (SC281)

There are a total of eight NPDES permitted facilities within the Derby (SC281) watershed. Of the eight permitted facilities, one is a non-discharging lagoon, one is a concrete operation, two are facilities utilizing industrial non-contact cooling water, three are facilities implementing groundwater remediation, and one is a municipal mechanical WWTP.

The non-discharging lagoon within the watershed is a one-cell lagoon operated by The Mann Cave. This facility is considered a temporary treatment system until the facility connects to municipal services. Because it is prohibited from discharging, The Mann Cave is not expected to contribute TP to the watershed.

The concrete operation within the watershed is CMC – West Robbins Plant. This facility is a ready-mix concrete operation and distribution terminal that generates wastewater from washing out concrete equipment. It uses settling pits for wash water and clear water is reused for on-site dust suppression. Domestic waste is discharged to the municipal sewer system or to an on-site septic tank. CMC – West Robbins Plant is not expected to contribute TP to the watershed.

The two facilities utilizing groundwater for non-contact cooling are Leading Technology Composites and Wescon Plastics, LLC; the former manufactures aircraft parts and the latter manufactures molded plastics. At both facilities, groundwater pumped on-site is used for cooling and then discharged to the Arkansas River without further treatment. Leading Technology Composites is not expected to further load their source water with TP and is not required to monitor for TP. Wescon Plastics, LLC adds chemicals for iron reducing bacteria, phosphorus sequestration, and sodium hypochlorite prior to use. From 2013 to 2015, Wescon Plastics, LLC monitored for TP, discharging a mean TP concentration of 0.19 mg/L. Both of these facilities discharge domestic waste to the municipal sewer system. Because of their potential and demonstrated TP contribution to the watershed, Leading Technology Composites and Wescon Plastics, LLC are assigned a nominal TP WLA under this TMDL.

The three facilities implementing groundwater remediation are: Air Capital Flight Line, LLC; Globe Engineering, Inc.; and McConnell Air Force Base. Air Capital Flight Line, LLC and McConnell Air Force Base are remediating fuel-contaminated groundwater and Globe Engineering, Inc. is removing VOCs. All three facilities treat their groundwater with an air stripper before discharging to the Arkansas River. Air Capital Flight Line, LLC is currently in the permit renewal process due to the sale of the company. The three facilities discharge domestic waste to the municipal sewer system. These systems are not expected to contribute to the TP impairment and are not required to monitor for TP; however, they are assigned a nominal WLA under this TMDL.

The municipal mechanical WWTP in the watershed is the City of Wichita WWTP (Lower Arkansas River Plant). It is the largest facility discharging to the Arkansas River watershed and currently operates at 32 MGD. From 2003 to 2010, the facility monitored monthly for TP. Since 2011, the facility is required to monitor weekly for TP. The discharge from the City of Wichita WWTP (Lower Arkansas River Plant) has a mean TP concentration of 4.07 mg/L. As a major TP contributor to this watershed, the City of Wichita WWTP (Lower Arkansas River Plant) is assigned a TP WLA under this TMDL.

Oxford (SC527)

There are a total of six NPDES permitted facilities within the Oxford (SC527) watershed. Of the six permitted facilities, three are non-discharging lagoons, one is a discharging lagoon, and two are municipal mechanical WWTPs.

The three non-discharging lagoons within the watershed are: Calvary Baptist Church, a one-cell lagoon; Fairway Meadows, a three-cell lagoon; and Prairie Schooner Mobile Home Park, a one-cell lagoon. Calvary Baptist Church is considered a temporary treatment system until the facility connects to municipal services. All three facilities are prohibited from discharging. They are not required to monitor for TP and are not expected to contribute TP to the watershed.

The discharging lagoon within the watershed is Long Branch Mobile Home Park. This facility is a two-cell lagoon that discharges to the Arkansas River. Since 2016, it has monitored TP quarterly when discharging. Long Branch Mobile Home Park currently discharges a mean TP concentration of 3.65 mg/L. This facility is currently not required to report discharge; however,

it has reported discharging for 10% of the quarters from 2008 to 2017. Using this TP concentration and the facility's design flow, Long Branch Mobile Home Park's discharging lagoon will be assigned a TP WLA under this TMDL.

The two municipal mechanical WWTPs in the watershed are the City of Derby WWTP and the City of Mulvane WWTP. The City of Derby WWTP currently operates at 1.7 MGD. The facility is required to monitor bimonthly for TP and has done so since 2003. This facility is designed for nutrient removal. Currently, the discharge from the City of Derby WWTP has a mean TP concentration of 2.58 mg/L. The City of Mulvane WWTP currently operates at 0.43 MGD. The facility is required to monitor monthly for TP and has done so since 2006; however, this facility was upgraded for nutrient removal in 2013, and its current TP concentration was derived using data from 2013 to 2017. Currently, its discharge has a mean TP concentration of 0.27 mg/L. Both WWTPs discharge to the Arkansas River. As TP contributors to this watershed, both the City of Derby and the City of Mulvane WWTPs are assigned TP WLAs under this TMDL.

Arkansas City (SC218)

There are a total of six NPDES permitted facilities within the Arkansas City (SC218) watershed. Of the six permitted facilities, one is a non-discharging lagoon, one is a water treatment plant (WTP), two are discharging lagoons, one is an industrial mechanical WWTP, and one is a municipal mechanical WWTP.

The non-discharging lagoon in the watershed is Camp Quaker Haven. This facility is a two-cell lagoon system that is prohibited from discharging. Camp Quaker Haven does not monitor for TP and is not expected to contribute TP to the watershed.

The WTP in the watershed is the City of Arkansas City WTP. This facility is a proposed plant that is currently inactive. In the future, this WTP will use groundwater to provide potable water to the City of Arkansas City. This facility will discharge rejected and neutralized water from reverse osmosis and backwash water from Greensand filtering. This discharge will blend with treated effluent from the City of Arkansas City WWTP before discharging to the Arkansas River. There will be a monitored outfall before the waste streams combine; however, the TP WLA for the City of Arkansas City WTP will be accounted for in the TP WLA for the City of Arkansas City WWTP under this TMDL.

The two discharging lagoons in the watershed are the City of Gueda Springs and the City of Oxford. Each facility is required to monitor TP quarterly when discharging but does not report discharge. The City of Gueda Springs operates a two-cell lagoon and currently discharges a mean TP concentration of 5.48 mg/L to Salt Creek. From 2008-2017, this facility discharged during approximately 23% of the quarters. The City of Oxford operates a three-cell lagoon and currently discharges a mean TP concentration of 1.92 mg/L to the Arkansas River. From 2008-2017, this facility discharged during approximately 33% of the quarters. Using their respective TP concentrations and design flows, the discharging lagoons for the City of Gueda Springs and the City of Oxford will be assigned TP WLAs under this TMDL.

The industrial mechanical WWTP in the watershed is Creekstone Farms Premium Beef, LLC. This facility is a meat processing facility that processes approximately 1,650 head of cattle per day. Creekstone Farms Premium Beef, LLC WWTP currently operates at 0.67 MGD. The facility is required to monitor weekly for TP and has done so since 2005. This facility is not designed for nutrient removal; however, it has been assessed for nutrient reduction capabilities. Currently, Creekstone Farms Premium Beef, LLC WWTP discharges a mean TP concentration of 23.0 mg/L to the Arkansas River. As the second largest TP load contributor to the Arkansas River watershed, the Creekstone Farms Premium Beef, LLC WWTP is assigned a TP WLA under this TMDL.

The municipal mechanical WWTP in the watershed is the City of Arkansas City WWTP. The City of Arkansas City WWTP currently operates at 1.32 MGD. The facility is required to monitor bimonthly for TP and has done so since 2014. Prior to this, the facility reported monthly and weekly TP concentrations from 2003 to 2014. This facility is not designed for nutrient removal. Currently, the City of Arkansas City WWTP discharges a mean TP concentration of 4.9 mg/L to the Arkansas River. As a TP contributor to this watershed, the City of Arkansas City WWTP is assigned a TP WLA under this TMDL.

MS4 Stormwater

The 11 MS4 permits within the Little Arkansas River and Arkansas River watersheds from Wichita to Arkansas City authorize each entity to discharge stormwater runoff (**Table 16**). Under these permits, the entities are expected to develop Stormwater Management Plans (SMPs) and implement Best Management Practices (BMPs) within their jurisdictions in order to reduce pollutant loading to waterbodies during precipitation events. Additionally, these permits require monitoring during four 24-hour, 0.5 inch precipitation events per year at designated outfalls. The following entities contribute MS4 regulated stormwater to the watershed: the cities of Kechi, Park City, and Valley Center contribute to the Little Arkansas River at Wichita (SC728) watershed; the City of Bel Aire contributes to the Arkansas River at Wichita (SC729) watershed; the City of Wichita, McConnell Air Force Base, Kansas Department of Transportation, and Sedgwick County contribute to multiple watersheds, including Derby (SC281); the cities of Derby and Mulvane contribute to the Oxford (SC527) watershed; and the City of Arkansas City contributes to the Arkansas City (SC218) watershed. Due to excessive TP concentrations from urban stormwater, runoff in these areas can potentially contribute to TP loads in these watersheds. As such, MS4 allocations were developed for each watershed under this TMDL.

Table 16. National Pollution Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System permits in the Little Arkansas River at Wichita (SC728) and the Arkansas River Watersheds from Wichita to Arkansas City.

Permitee	KS Permit Number	NPDES Permit Number	Permit Expiration	SC Site
City of Kechi	M-LA09-SU01	KSR410013	01/31/19	SC728
City of Park City	M-LA19-SU01	KSR410027	01/31/19	SC728
City of Valley Center	M-LA16-SU01	KSR410037	01/31/19	SC728
City of Bel Aire	M-LA23-SU01	KSR410002	01/31/19	SC729

Permitee	KS Permit Number	NPDES Permit Number	Permit Expiration	SC Site
City of Wichita	M-AR94-SO01	KS0091049	07/31/19	SC728, SC729, SC281
McConnell Air Force Base	F-AR94-SU01	KSR410018	01/31/19	SC281
Kansas Department of Transportation	M-AR94-SU02	KSR410012	01/31/19	SC728, SC729, SC281, SC527
Sedgwick County	M-AR94-SU01	KSR410032	01/31/19	SC728, SC729, SC281, SC527
City of Derby	M-AR29-SU01	KSR410004	01/31/19	SC527
City of Mulvane	M-AR64-SU01	KSR410024	01/31/19	SC527
City of Arkansas City	M-AR06-SN01	KSR440001	01/31/19	SC218

Livestock and Waste Management Systems:
There are ten certified or permitted Animal Feeding Operations (AFOs) or Concentrated Animal Feeding Operations (CAFOs) within the Arkansas River watershed from Wichita to Arkansas City (**Table 17**). None of these facilities are large enough to require a federal permit. There are no AFOs or CAFOs in the Arkansas River at Wichita (SC729) and Derby (SC281) watersheds due to their high urbanization. In the remaining watersheds, there is one operation in the Little Arkansas River at Wichita (SC728) watershed, five operations in the Oxford (SC527) watershed, and four operations in the Arkansas City (SC218) watershed.

The Arkansas River watershed lies within Cowley, Sedgwick, and Sumner counties. As of the 2012 U.S. Department of Agriculture Census, the total number of livestock in these three counties is approximately 126,000. The primary livestock industry within this region is cattle, with approximately 107,000 head (**Table 18**). The second most prevalent livestock industry is sheep and lambs, with approximately 4,800 head, followed by poultry, with approximately 4,000 birds. From 2007 to 2012, there has been a decline in all livestock categories except sheep and lambs and goats. The most drastic decline occurred in swine, which decreased by 76%. These trends are generally consistent within the individual counties, as well, with the exceptions of an increase in poultry in Sedgwick County, a decrease in goats in Sedgwick County, and a decrease in sheep and lambs in Sumner County.

Table 17. Certified or permitted Animal Feeding Operations or Concentrated Animal Feeding Operations in the Arkansas River watershed from Wichita to Arkansas City.

KS Permit Number	County	Animal Total	Permit Type	Animal Type
Little Arkansas River at Wichita (SC728)				
A-LASG-BA01	Sedgwick	100	Certification	Beef
Arkansas River at Oxford (SC527)				
A-ARCL-BA06	Cowley	100	Certification	Beef
A-ARCL-BA08	Cowley	40	Certification	Beef
A-ARCL-BA09	Cowley	300	Certification	Beef
A-ARSG-BA25	Sedgwick	200	Certification	Beef
A-ARSU-BA10	Sumner	350	Certification	Beef
Arkansas River at Arkansas City (SC218)				
A-ARCL-BA02	Cowley	600	Certification	Beef
A-ARCL-BA05	Cowley	300	Certification	Beef
A-ARCL-S001	Cowley	1,000	Permit	Swine
A-ARSU-M005	Sumner	295	Permit	Dairy

Table 18. Agricultural census results for livestock in the counties within the Arkansas River watershed from Wichita to Arkansas City, 2007 and 2012 (U.S. Department of Agriculture, 2012).

County	Year	Cattle and Calves	Swine	Poultry	Sheep and Lambs	Goats
Cowley	2007	58,170	5,742	1,511	678	872
	2012	47,793	117	1,455	1,044	1,218
	Percent Change	-18	-98	-4	54	40
Sedgwick	2007	34,551	3,336	1,540	1,471	1,219
	2012	29,784	1,990	1,624	3,034	819
	Percent Change	-14	-40	5	106	-33
Sumner	2007	39,499	4,060	1,225	1,858	503
	2012	29,132	1,076	949	764	618
	Percent Change	-26	-73	-23	-59	23
Total	**2007**	**132,220**	**13,138**	**4,276**	**4,007**	**2,594**
	2012	**106,709**	**3,183**	**4,028**	**4,842**	**2,655**
	Percent Change	**-19**	**-76**	**-6**	**21**	**2**

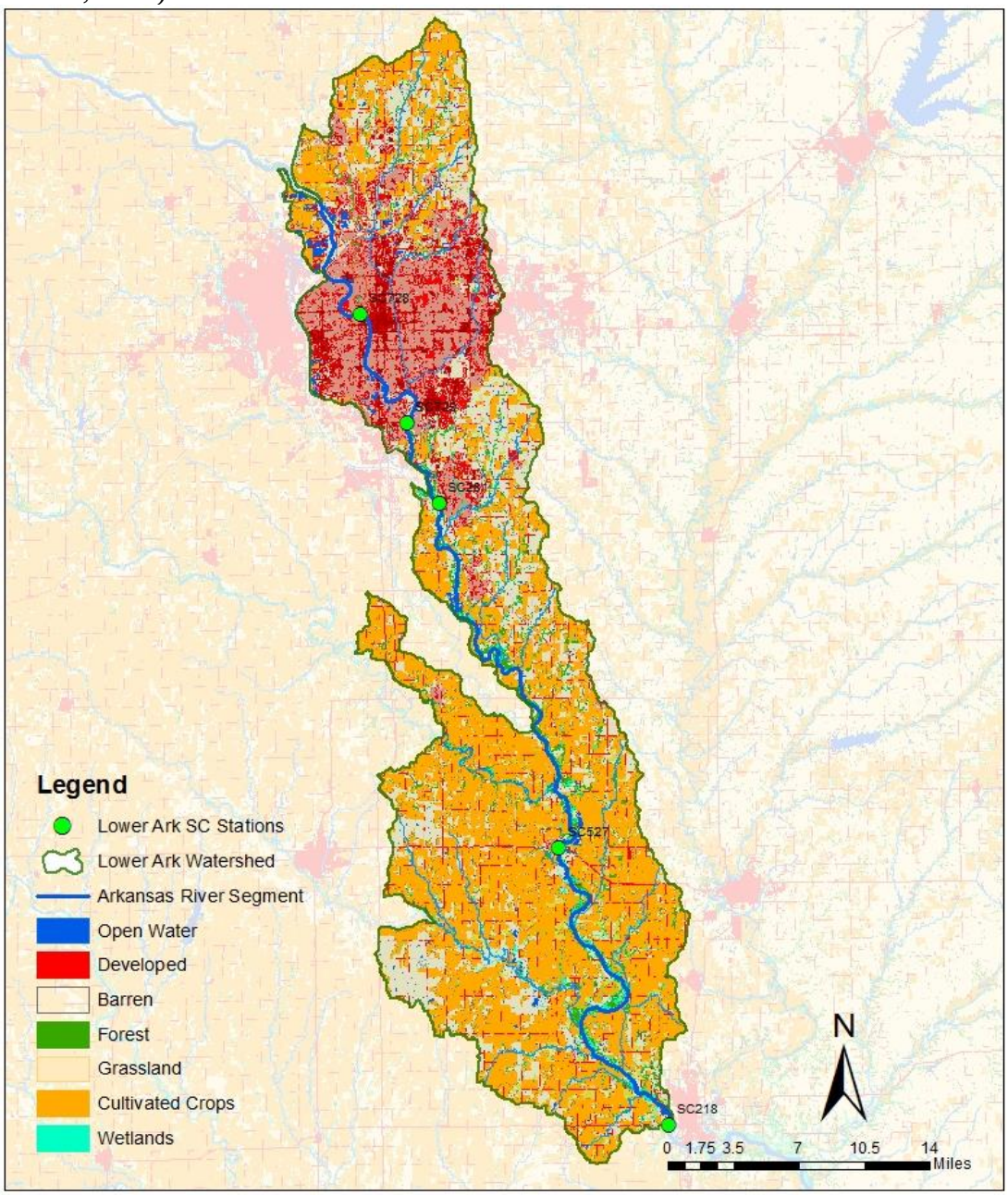
All permitted livestock facilities have waste management systems designed to minimize runoff entering their operations and detain runoff emanating from their facilities. These facilities are designed to retain a 25-year, 24-hour rainfall or runoff event, as well as an anticipated two weeks of normal wastewater, from their operations. Typically, this rainfall event coincides with streamflow that occurs less than 1-5% of the time. It is unlikely TP loading would be attributable to properly operating permitted facilities, though extensive loading may occur if any of these facilities were in violation and discharged. Therefore, all AFOs within the Arkansas River watershed from Wichita to Arkansas City are assigned a WLA of zero.

Land Use:
The 2011 National Land Cover Database indicates that land use in the Arkansas River watershed from Wichita to Arkansas City predominantly consists of cultivated crops (43%), grassland (26%), and developed land (23%; **Table 19**; **Figure 71**). Consistent with the overall trend for the Arkansas River watershed, the Little Arkansas River at Wichita (SC728), Oxford (SC527), and Arkansas City (SC218) watersheds are dominated by cultivated crops, with 36, 49, and 59% cropland, respectively. These watersheds have an increased potential for nutrient runoff from fertilized cropland, which can contribute to TP loads in these watersheds. The Arkansas River at Wichita (SC729) and Derby (SC281) watersheds, however, are dominated by developed land, with 81 and 68% of the watersheds developed, respectively. Built infrastructure and impervious surfaces in urban environments increase runoff, which can contribute to TP loads in these watersheds.

Table 19. Land cover in the Arkansas River watershed from Wichita to Arkansas City (Homer et al., 2015).

Watershed	Cultivated Crops (%)	Grassland (%)	Developed Land (%)	Open Water (%)	Forest (%)	Wetlands (%)	Barren Land (%)	Land Area (acres)
Little Arkansas River at Wichita (SC728)	36	34	24	2	3	1	0	51,495
Arkansas River at Wichita (SC729)	4	10	81	4	1	0	0	53,216
Derby (SC281)	6	18	68	4	4	1	0	18,438
Oxford (SC527)	49	31	10	3	6	2	0	112,277
Arkansas City (SC218)	59	27	5	2	4	3	0	142,152
Total	**43**	**26**	**23**	**2**	**4**	**2**	**0**	**377,578**

Figure 71. Map of land cover in the Arkansas River watershed from Wichita to Arkansas City (Homer et al., 2015).



Population Density:
The Arkansas River watershed includes 13 cities and has a combined population of approximately 425,000, according to the 2010 census from the U.S. Census Bureau (**Table 20**). From the 2000 to the 2010 census, the total population within this region increased by 9%, with the largest growth occurring in the City of Wichita and its suburbs. Overall, the Kansas Water Office estimates that by 2040 the total population within this region will increase by 25%, again with the largest growth occurring in the City of Wichita and its suburbs.

Table 20. Census results from 2000 and 2010 (U.S. Census Bureau, 2010) and population projections for 2040 (Kansas Water Office, 2002) for cities in the Arkansas River watershed from Wichita to Arkansas City.

City	Population, 2000	Population, 2010	Population Projection, 2040	Population Change, 2000 to 2010 (%)	Projected Population Growth, 2010 to 2040 (%)
Little Arkansas River at Wichita (SC728)					
Kechi	893	1,150	1,922	29	67
Valley Center	4,212	4,766	6,428	13	35
Park City	5,956	6,991	10,099	17	44
Arkansas River at Wichita (SC729)					
Bel Aire	5,452	7,092	12,014	30	69
Arkansas River at Derby (SC281)					
Wichita	331,672	357,984	436,922	8	22
Eastborough	872	844	762	-3	-10
Arkansas River at Oxford (SC527)					
Derby	19,559	24,440	39,083	25	60
Mulvane	5,342	5,903	7,585	11	28
Bell Plaine	1,858	2,061	2,668	11	29
Udall	809	799	769	-1	-4
Oxford	1,201	1,211	1,244	1	3
Gueda Springs	209	201	179	-4	-11
Arkansas River at Arkansas City (SC218)					
Arkansas City	12,078	11,512	9,814	-5	-15
Total	**390,113**	**424,954**	**529,489**	**9**	**25**

On-Site Waste Systems:
The Arkansas River watershed from Wichita to Hutchinson consists of three counties: Cowley, Sedgwick, and Sumner. Cowley and Sedgwick counties serve a predominantly urban population, with 69 and 92% of their populations classified as urban, respectively (**Table 21**; U.S. Census Bureau, 2010); however, Sumner County predominantly serves a rural population, with 63% of its population classified as rural. Overall, the watershed consists of a population that is 88% urban and 12% rural. Since the majority of the population is considered urban, most residents in this region are likely connected to a municipal sewer system. The portion of the population classified as rural, however, may not be connected to a municipal sewer system. According to the U.S. Environmental Protection Agency's Spreadsheet Tool for Estimating Pollutant Load (STEPL), there are a total of 1,630 septic systems located in this watershed. Septic systems in the state of Kansas typically have an estimated 10-15% failure rate (Electric Power Research Institute provided by U.S. Environmental Protection Agency, 2017). Failing on-site septic systems have the potential to contribute to nutrient loading in the watershed. However, because of their small flows and the proclivity of phosphorus to adsorb to soil, failing on-site septic systems are considered a minor source of TP loading within the watershed and do not significantly contribute to TP impairment in the Arkansas River.

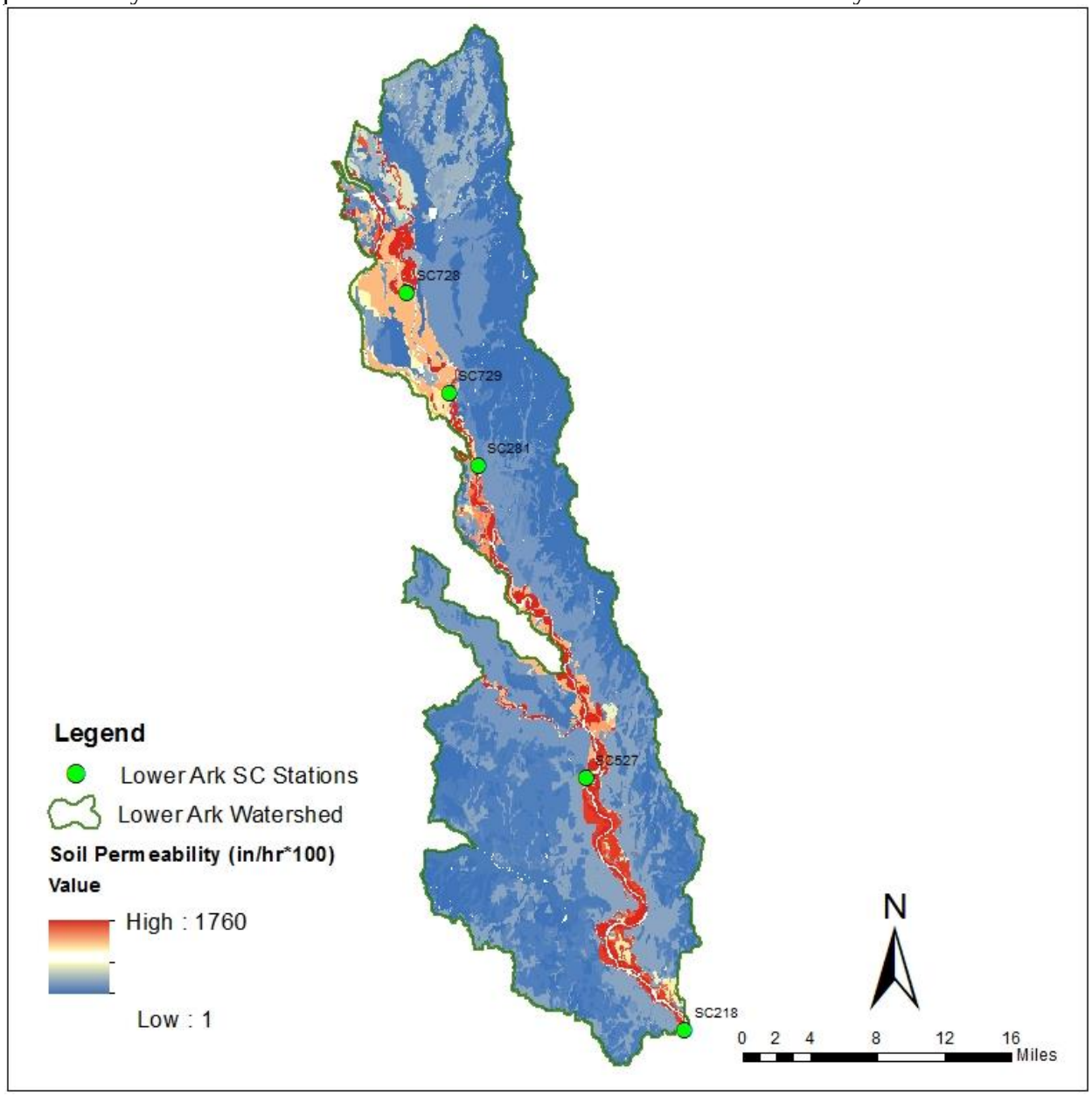
Table 21. Census results by urban and rural population for counties in the Arkansas River watershed from Wichita to Hutchinson (U.S. Census Bureau, 2010).

County	Classification	Population, 2010	Percent
Cowley	Urban	25,055	69
	Rural	11,256	31
Sedgwick	Urban	460,197	92
	Rural	38,168	8
Sumner	Urban	8,964	37
	Rural	15,168	63
Total	**Urban**	**494,216**	**88**
	Rural	**64,592**	**12**

Contributing Runoff:

Runoff conditions can occur as a result of either infiltration-excess (precipitation exceeds the infiltration rate of the soil) or saturation-excess (precipitation falls on soils saturated due to an elevated water table), causing overland flow (Juracek, 2000). Overland flow can impact the quality of water entering streams, thereby impacting water-quality loads. Soil permeability categories in Kansas have been defined by the following criteria in inches per hour (in/hr): very high (3.43 in/hr), high (2.86 in/hr), moderate (2.29 in/hr), low (1.71 in/hr), very low (1.14 in/hr), and extremely low (0.57 in/hr; Juracek, 2000). According to the Natural Resources Conservation Service (NRCS) State Soil Geographic Database (STATSGO), the Arkansas River watershed from Wichita to Arkansas City has a soil permeability range of 0.01 to 13 in/hr (**Figure 72**). Within the watershed, 34% of the area has a soil permeability less than 1.71 in/hr; overall, the Arkansas River watershed has a mean soil permeability of 1.65 in/hr, placing it in the very low permeability category. Within the Little Arkansas River at Wichita (SC728) watershed, 49% of the area has a soil permeability of less than 1.71 in/hr; the watershed has a mean soil permeability of 1.17 in/hr, placing it in the very low permeability category. Within the Arkansas River at Wichita (SC729) watershed, 23% of the area has a soil permeability of less than 2.86 in/hr; the watershed has a mean soil permeability of 2.36 in/hr, placing it in the moderate permeability category. Within the Derby (SC281) watershed, 14% of the area has a soil permeability of less than 3.43 in/hr; the watershed has a mean soil permeability of 3.22 in/hr, placing it in the high permeability category. Within the Oxford (SC527) watershed, 36% of the area has a soil permeability of less than 2.29 in/hr; the watershed has a mean soil permeability of 1.78 in/hr, placing it in the low permeability category. Within the Arkansas City (SC218) watershed, 45% of the area has a soil permeability of less than 1.71 in/hr; the watershed has a mean soil permeability of 1.25 in/hr, placing it in the very low permeability category.

Figure 72. Map of Natural Resources Conservation Service State Soil Geographic Database soil permeability in the Arkansas River watershed from Wichita to Arkansas City.



Background Levels:
Phosphorus is present over the landscape and in the soil profile. It is also present in terrestrial and aquatic biota. These biota can contribute to phosphorus loadings, particularly if they congregate to a density that exceeds the assimilative capacity of the land or water.

4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

The endpoints for these TMDLs are based on the biological condition, pH, sestonic chlorophyll-*a*, and dissolved oxygen concentrations, all of which should improve to a level of full attainment of designated uses as phosphorus concentrations decrease in the Little Arkansas and Arkansas Rivers.

This TMDL is established as two phases to reduce phosphorus loadings and total phosphorus concentrations with periodic assessment of the biological condition in the river. The Phase I total phosphorus management milestone in the Little Arkansas River (SC728), and the Arkansas River at Derby (SC281), Oxford (SC527), and Arkansas City (SC218) is 0.374 mg/L, reflecting the third quartile of median total phosphorus concentrations for KDHE stations located within Level III Ecoregion 27. In the Arkansas River at Wichita (SC729) the Phase I milestone is 0.200 mg/L and reflects the median of station medians in Level III Ecoregion 27.

The Phase II total phosphorus milestone for all watersheds covered by this TMDL is 0.130 mg/L, reflecting the first quartile of median total phosphorus concentrations for KDHE stations located within Level III Ecoregion 27.

Phase I point source load reductions required from mechanical wastewater treatment plants operated by the cities of Wichita (M-AR94-IO01), Derby (M-AR29-OO02), Arkansas City (M-AR06-IO01), and Creekstone Farms (I-AR06-PO06). In addition, it is expected the best management practices prescribed in the MS4 permits within the watershed will be implemented by the permitted entities to the maximum extent practicable during precipitation events. Furthermore, the application of riparian and livestock agricultural best management practices should continue in order to abate and reduce total phosphorus loading from nonpoint sources.

Once the concentrations in the Little Arkansas and Arkansas Rivers approach Phase I milestones, an intensive assessment of macroinvertebrate abundance and diversity will be performed to determine compliance with the narrative nutrient criteria. Presuming one or more of the numeric endpoints are not met at the end of Phase I, Phase II will commence with a TP milestone of a median concentration of 0.130 mg/L with additional reductions in loads and phosphorus concentrations accomplished through enhanced implementation of controls on both point and nonpoint sources in the watershed.

Point Sources: The Phase I wasteload allocations (WLA) associated with the facilities discharging in the watershed are detailed in **Table 22**. A complete list of NPDES permitted facilities in the TMDL watersheds can be found in **Appendix A.** The five concrete plants have Phase I and Phase II wasteload allocations of zero as they are not expected to contribute to the phosphorus loads in their respective watersheds. The City of Arkansas City drinking water plant, ten groundwater remediation sites, seven facilities discharging non-contact cooling water, and the Spirit Aerosystems facility treating industrial waste have Phase I and Phase II wasteload allocations calculated at a nominal TP concentration of 0.2 mg/L and facility design flow, as they

are expected to contribute only nominal phosphorus loads to their respective watersheds. Two groundwater remediation facilities, Gilbert and Mosley and Cessna Aircraft – Pawnee were assigned Phase I and Phase II wasteload allocations at the current concentration of TP in their discharge and facility design flow.

Wasteload allocations for the three lagoon systems treating domestic waste have been assigned Phase I and Phase II wasteload allocations calculated using facility design flow and 2 mg/L TP, an effluent TP concentration commonly seen from Kansas lagoon systems.

Phase I wasteload allocations for the Chisholm Creek Utility Authority, and the Cities of Valley Center, Wichita, Derby, and Arkansas City municipal mechanical facilities were calculated with an effluent total phosphorus concentration of 1 mg/L at the facility design flow. For Phase II, the municipal waste treatment facilities operated by Chisholm Creek Utility Authority, and the Cities of Valley Center, Wichita, Derby and Arkansas City may need to implement enhanced nutrient reduction (ENR) technologies to meet their Phase II WLA calculated with a TP concentration of 0.5 mg/L and facility design flow.

Phase I and II wasteload allocation for the major industrial discharger in the TMDL watershed, Creekstone Farms, was calculated at 4 mg/L total phosphorus and design flow.

In addition, a wasteload allocation of 149.94 lbs/day totaling 54,728.10 lbs/year TP has been reserved in anticipation of further development in the Little Arkansas River watershed above Wichita and in the Arkansas River Watershed from Wichita to its confluence with the Walnut River. This reserve may be portioned and applied to new or expanded NPDES permitted facilities discharging to any one of the segments in the SC728, SC729, SC281, SC527, or SC218 watersheds.

Table 22. Phase 1 Wasteload allocations for facilities permitted to discharge to the Arkansas River from Wichita to the terminus of segment 110300131 below Arkansas City.

SC Site	Permit #	Permitee	Design Flow (MGD)	Anticipated TP Concentration (mg/L)	TP WLA Daily Load (lbs/day)	TP WLA Annual Load (lbs/year)
SC728	M-LA19-OO02	Chisholm Creek Utility Authority	2.16	1	18.0	6,570.00
	M-LA16-OO02	City of Valley Center	0.7	1	5.80	2,117.00
	Phase I Wasteload Allocation in the Little Arkansas River Watershed (SC728)				*23.80*	*8,687.00*
SC729	I-AR94-PR09	Andale Ready Mix	*	0	0	0
	I-AR94-PR16	CMC Plant 1 - South Madison Plant	*	0	0	0
	I-AR94-PR10	VMC	*	0	0	0

SC Site	Permit #	Permitee	Design Flow (MGD)	Anticipated TP Concentration (mg/L)	TP WLA Daily Load (lbs/day)	TP WLA Annual Load (lbs/year)
SC729	I-AR94-PR12	Wichita Concrete Pipe Company	*	0	0	0
	I-AR94-CO47	Friends University	0.0288	0.2	0.05	18.25
	I-AR94-PO08	Hospitality Real Estate Corporation	0.0011	0.2	0.002	0.73
	I-AR94-PO19	Lubrication Engineers, Inc.	0.024	0.2	0.04	14.60
	I-AR94-CO10	The Coleman Company, Inc. - Northeast Plant	0.018	0.2	0.03	10.95
	I-AR94-PO46	Boeing Wichita	0.169	0.2	0.28	102.20
	I-AR94-PO78	El Paso Merchant Energy	0.0144	0.2	0.02	7.30
	I-AR94-PO06	Koch-Glitsch	0.0864	0.2	0.14	51.10
	I-AR94-PO80	Gilbert & Mosley	1.325	0.34	3.76	1,372.40
	I-AR94-PO21	New Coleman Holdings, Inc.	0.5	0.2	0.84	306.60
	I-AR94-PO76	The Coleman Company, Inc. - Factories A and B	0.1728	0.2	0.29	105.85
	I-AR94-PO70	The Coleman Company, Inc. - Northeast	0.2304	0.2	0.38	138.70
	I-AR94-PO12	Union Pacific Railroad	0.144	0.2	0.24	87.60
	I-AR94-PO04	Beechcraft Corporation	0.082	0.2	0.14	51.10
	I-AR94-PO05	Cessna Aircraft Company - Pawnee Facility	0.2076	0.28	0.49	178.85
	I-AR94-PO20	Spirit Aerosystems, Inc	1.8	0.2	3.01	1,098.65
	Phase I Wasteload Allocation for the Lower Arkansas River Watershed in Wichita (SC729)				*9.712*	*3,544.88*
SC281	I-AR94-PR07	CMC - West Robbins Plant	*	0	0	0
	I-AR94-CO50	Leading Technology Composites	0.02	0.2	0.03	10.95

SC Site	Permit #	Permitee	Design Flow (MGD)	Anticipated TP Concentration (mg/L)	TP WLA Daily Load (lbs/day)	TP WLA Annual Load (lbs/year)
SC281	I-AR94-PO62	Wescon Plastics, LLC	0.36	0.2	0.60	219.00
	I-AR94-PO90	Air Capital Flight Line, LLC	0.086	0.2	0.14	51.10
	I-AR94-PO31	Globe Engineering Company	0.262	0.2	0.44	160.60
	F-AR94-PO25	McConnell Air Force Base	0.064	0.2	0.11	40.15
	M-AR94-IO01	City of Wichita - Lower Arkansas River Plant	54	1	451.11	164,655.15
	Phase I Wasteload Allocation for the Lower Arkansas River Watershed at Derby (SC281)				*452.43*	*165,136.95*
SC527	C-AR94-OO07	Long Branch Mobile Home Park	0.01675	2	0.28	102.20
	M-AR29-OO02	City of Derby	2.5	1	20.88	7,621.20
	M-AR64-OO02	City of Mulvane	1	1	8.35	3,047.75
	Phase I Wasteload Allocation for the Lower Arkansas River Watershed at Oxford (SC527)				*29.51*	*10,771.15*
SC218	I-AR06-PO10	City of Arkansas City	0.024	0.2	0.04	14.60
	M-AR36-OO01	City of Geuda Springs	0.01392	2	0.23	83.95
	M-AR68-OO01	City of Oxford	0.181	2	3.02	1,102.30
	I-AR06-PO06	Creekstone Farms Premium Beef, LLC	1.25	4	41.77	15,246.05
	M-AR06-IO01	City of Arkansas City	4.7	1	39.26	14,329.90
	Phase I Wasteload Allocation in the Lower Arkansas River Watershed from Oxford (SC527) to the terminus of segment 110300131				*84.32*	*30,776.80*
Reserve Wasteload Allocation for the Lower Arkansas Watershed including Little Arkansas River at Wichita (SC728) and the Arkansas River from Wichita (SC729) to the terminus of segment 110300131					***149.94***	***54,728.10***
Total Phase I Wasteload Allocation for the Little Arkansas River Watershed (SC728) and the Lower Arkansas River Watershed from Wichita (SC729) to the terminus of segment 110300131 at its confluence with the Walnut River					**749.71**	**273,644.88**

Figures 73-77 display current seasonal loading, the Phase I TMDL and load and wasteload allocations at KDHE stream chemistry stations on the Little Arkansas River at Wichita (SC728) and on the Arkansas River near Wichita (SC729), Derby (SC281), Oxford (SC527), and Arkansas City (SC218). Current condition, Phase I and II load, wasteload, and stormwater (MS4) allocations for each station can be seen in **Tables 23-27**. The reserve wasteload is also displayed in **Table 27.**

Calculated load capacities in Figures 73-77 and Tables 23-27 are based on total phosphorus management milestones and the estimated flow condition in the river. For the purposes of assessing the loading capacity along the main stem Arkansas River from Wichita to the segment terminus below Arkansas City, it is assumed that tributaries not included in this TMDL watershed are meeting the management milestones established by this document and any specific loads for those tributaries, if needed, will be established by a future TMDL. Once TP loading from tributaries is accounted for, incremental loading along the mainstem can be estimated by subtracting the upstream load from the downstream loading capacity to assess incremental loading along the reaches of the river.

Figure 73. Phase I load capacity (TMDL) and wasteload allocation with current, seasonal loads displayed across the flow duration curve for the Little Arkansas River at Wichita (SC728).

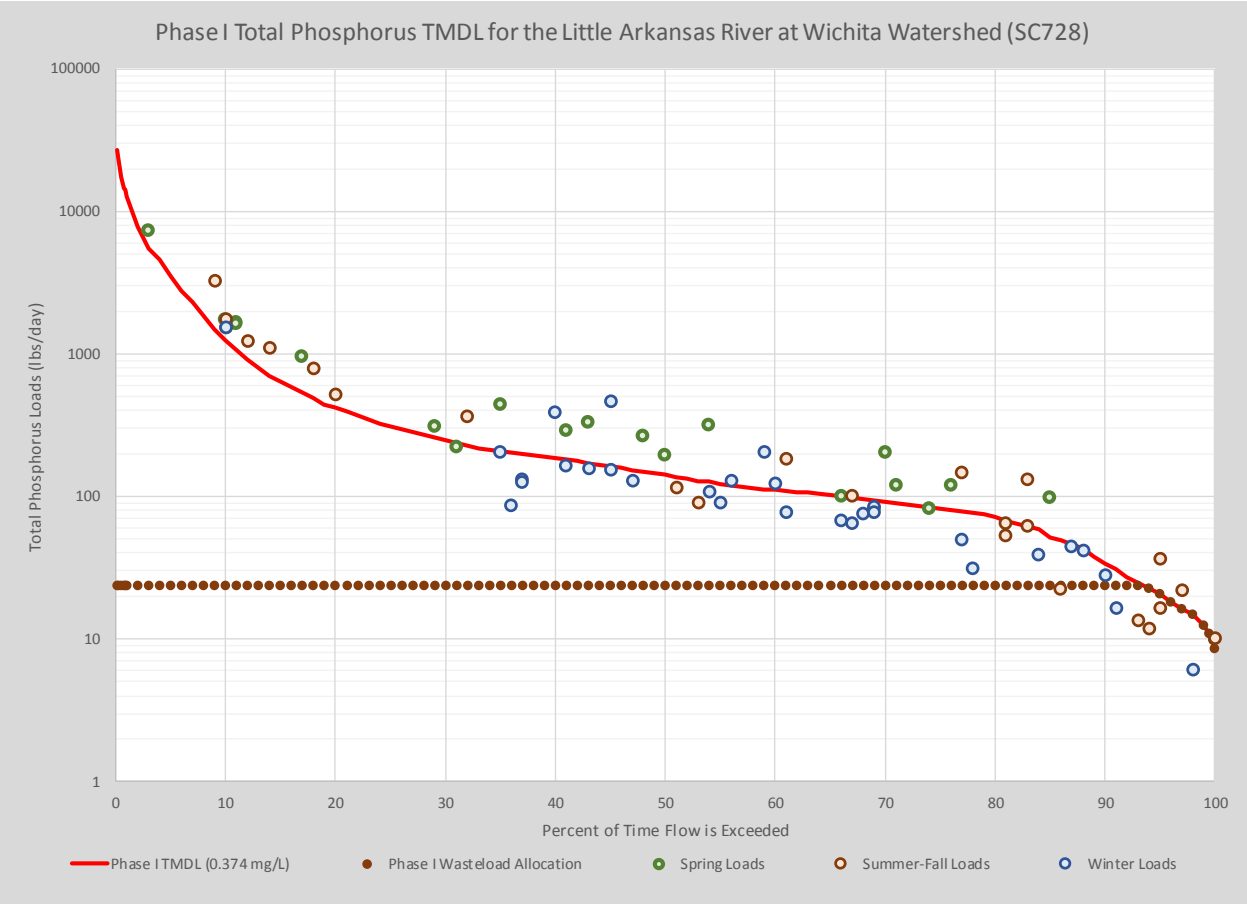


Table 23. Phase I and II load capacity (TMDL), wasteload, and MS4 allocation in the Little Arkansas River at Wichita (SC728) watershed.

Percent Flow Exceedance	Flow at SC7288 (cfs)	Current Condition (lbs/day)	Load Capacity (lbs/day)	Wasteload Allocation (lbs/day)	MS4 Allocations (lbs/day)	Reserve MS4 Allocation (lbs/day)	Load Allocation (lbs/day)
Phase I							
90%	16.80	37.10	33.93	23.80	1.00	0.51	8.62
75%	40.77	90.04	82.34	23.80	2.00	2.00	54.54
50%	70.00	154.60	141.37	23.80	50.56	3.35	63.66
25%	154.56	341.36	312.15	23.80	123.99	8.22	156.14
10%	612.64	1353.08	1237.29	23.80	521.80	34.58	657.11
Phase II							
90%	16.80	37.10	11.79	11.79	0.00	0.00	0.00
75%	40.77	90.04	28.62	11.94	2.00	2.00	12.68
50%	70.00	154.60	49.14	11.94	12.28	1.25	23.67
25%	154.56	341.36	108.50	11.94	31.87	3.23	61.46
10%	612.64	1353.08	430.07	11.94	137.98	14.01	266.14

Figure 74. Phase I load capacity (TMDL) and wasteload allocation with current, seasonal loads displayed across the flow duration curve for the Arkansas River at Wichita (SC758).

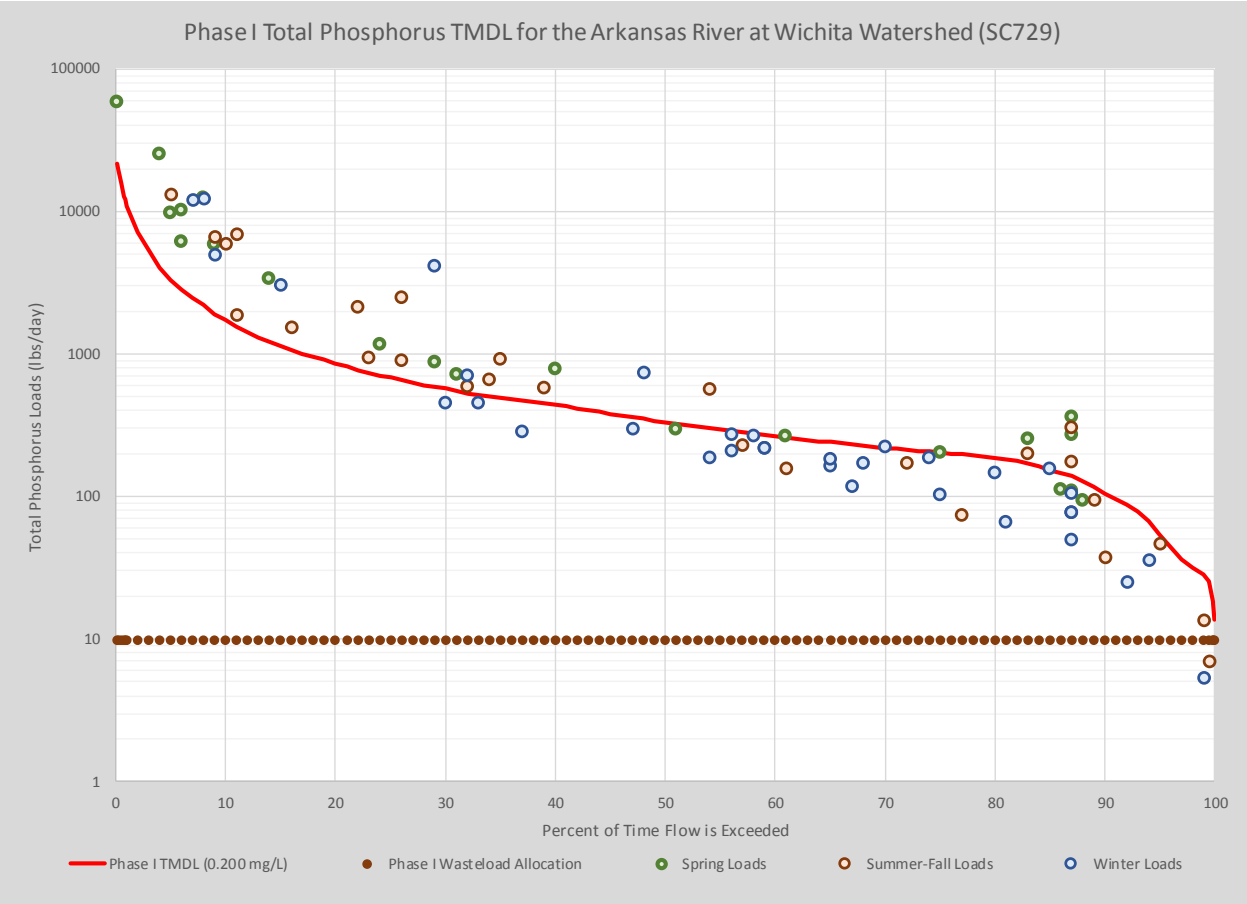


Table 24. Phase I and II load capacity (TMDL), wasteload, and MS4 allocation in the Arkansas River at Wichita (SC729) watershed.

Percent Flow Exceedance	Flow at SC7288 (cfs)	Current Condition (lbs/day)	Load Capacity (lbs/day)	Wasteload Allocation (lbs/day)	MS4 Allocations (lbs/day)	Reserve MS4 Allocation (lbs/day)	Load Allocation (lbs/day)
Phase I							
90%	96.66	123.71	104.396	9.712	1.000	1.000	92.684
75%	187.32	239.73	202.300	9.712	2.000	2.000	188.588
50%	308.02	394.20	332.660	9.712	125.401	9.877	187.670
25%	629.06	805.07	679.383	9.712	260.035	20.482	389.154
10%	1,602.70	2051.13	1730.912	9.712	668.346	52.643	1000.211
Phase II							
90%	96.66	123.71	67.857	9.712	1.000	1.000	56.145
75%	187.32	239.73	131.495	9.712	2.000	2.000	117.783
50%	308.02	394.20	216.229	9.712	81.511	6.250	118.756
25%	629.06	805.07	441.599	9.712	170.463	13.071	248.353
10%	1,602.70	2051.13	1125.093	9.712	440.234	33.757	641.390

Figure 75. Phase I load capacity (TMDL) and wasteload allocation with current, seasonal loads displayed across the flow duration curve for the Arkansas River at Derby (SC281).

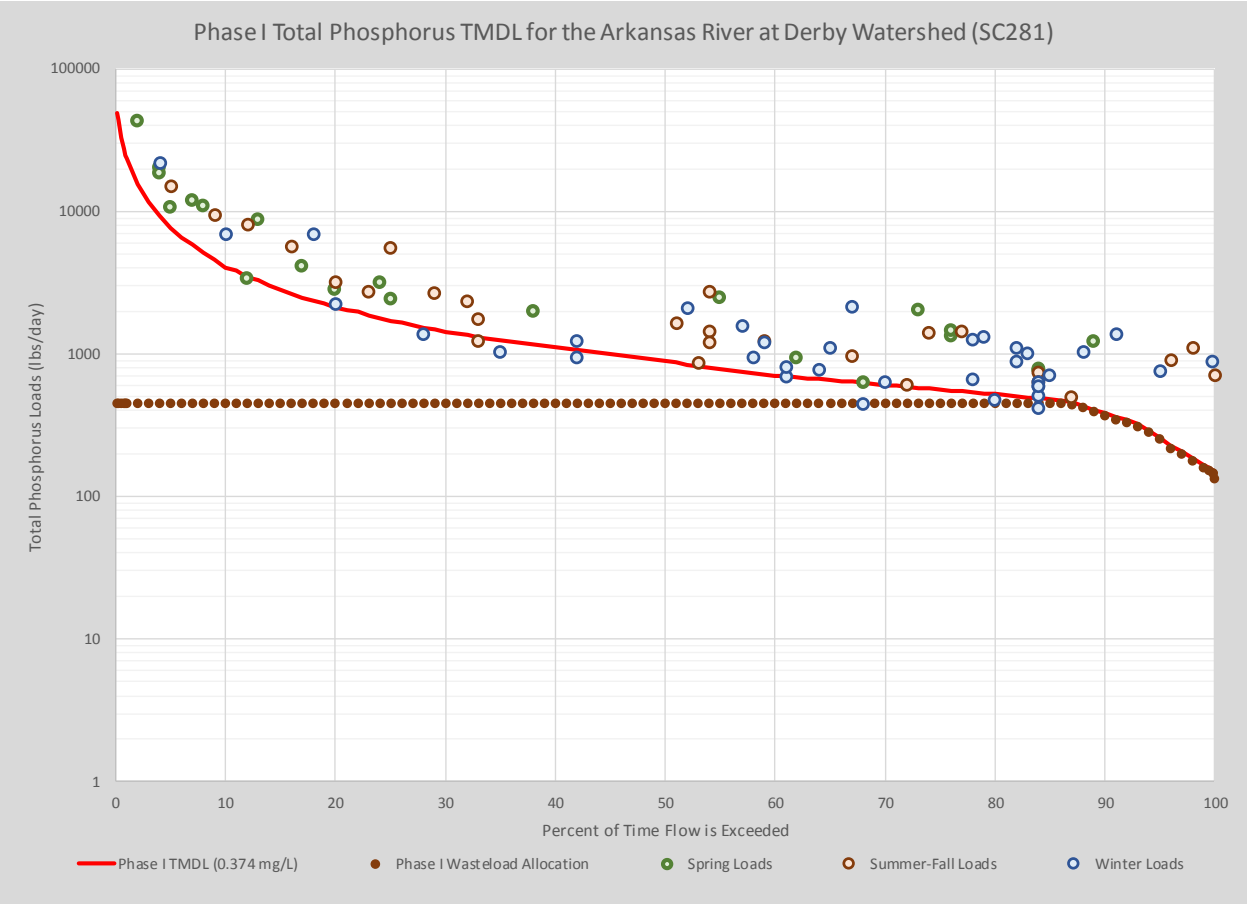


Table 25. Phase I and II load capacity (TMDL), wasteload, and MS4 allocation in the Arkansas River at Derby (SC281) watershed.

Percent Flow Exceedance	Flow at SC281 (cfs)	Current Condition (lbs/day)	Load Capacity (lbs/day)	Wasteload Allocation (lbs/day)	MS4 Allocations (lbs/day)	Reserve MS4 Allocation (lbs/day)	Load Allocation (lbs/day)
Phase I							
90%	190.90	669.03	385.54	372.14	0.00	0.00	13.40
75%	280.00	981.29	565.49	452.43	2.00	2.00	109.06
50%	439.00	1538.52	886.60	452.43	70.22	18.20	345.75
25%	841.75	2950.00	1700.00	452.43	201.77	52.29	993.51
10%	2,020.00	7079.29	4079.59	452.43	586.63	152.03	2888.50
Phase II							
90%	190.90	621.61	134.01	134.01	0.00	0.00	0.00
75%	280.00	911.74	196.56	196.56	0.00	0.00	0.00
50%	439.00	1429.47	308.18	226.87	24.41	2.84	54.06
25%	841.75	2740.91	590.91	226.87	109.28	12.74	242.02
10%	2,020.00	6577.52	1418.04	226.87	357.58	41.68	791.91

Figure 76. Phase I load capacity (TMDL), and wasteload allocation with current, seasonal loads displayed across the flow duration for the Arkansas River at Oxford (SC527).

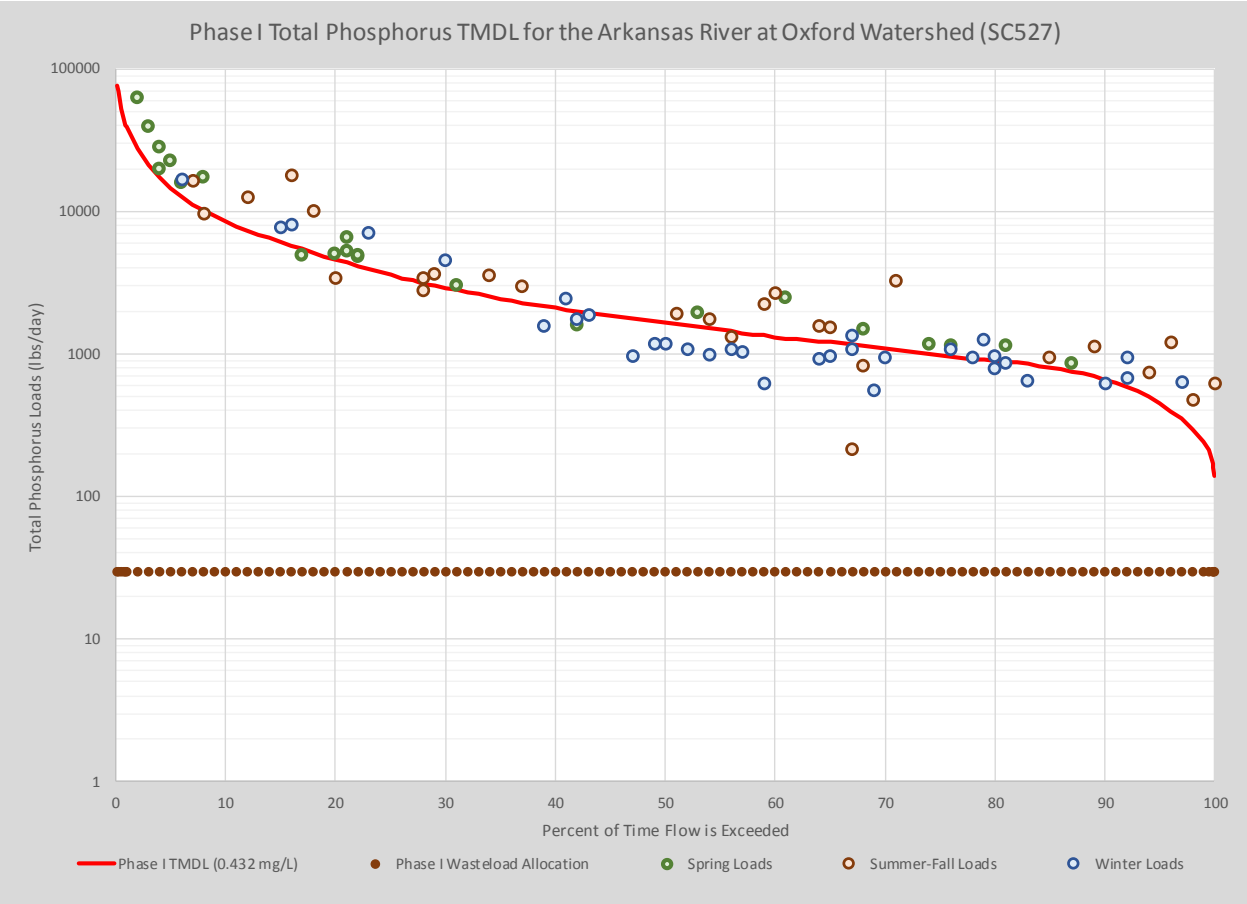


Table 26. Phase I and II load capacity (TMDL), wasteload, and MS4 allocation in the Arkansas River at Oxford (SC527) watershed.

Percent Flow Exceedance	Flow at SC527 (cfs)	Current Condition (lbs/day)	Load Capacity (lbs/day)	Wasteload Allocation (lbs/day)	MS4 Allocations (lbs/day)	Reserve MS4 Allocation (lbs/day)	Load Allocation (lbs/day)
Phase I							
90%	327.91	764.95	662.25	29.51	1.00	1.00	630.74
75%	482.34	1125.19	974.12	29.51	2.00	2.00	940.61
50%	822.26	1918.17	1660.64	29.51	27.46	80.18	1523.48
25%	1782.71	4158.71	3600.36	29.51	60.12	175.54	3335.20
10%	4240.34	9891.86	8563.79	29.51	143.68	419.53	7971.07
Phase II							
90%	327.91	764.95	230.19	14.90	1.00	1.00	213.29
75%	482.34	1125.19	338.60	14.90	2.00	2.00	319.70
50%	822.26	1918.17	577.23	14.90	9.80	27.63	524.90
25%	1782.71	4158.71	1251.46	14.90	21.24	60.77	1154.55
10%	4240.34	9891.86	2976.72	14.90	50.53	145.56	2765.73

Figure 77. Phase I load capacity (TMDL) and wasteload allocation with current, seasonal loads displayed across the flow duration curve for the Arkansas River at Arkansas River segment 1 (CUSEGA 110300131) terminus.

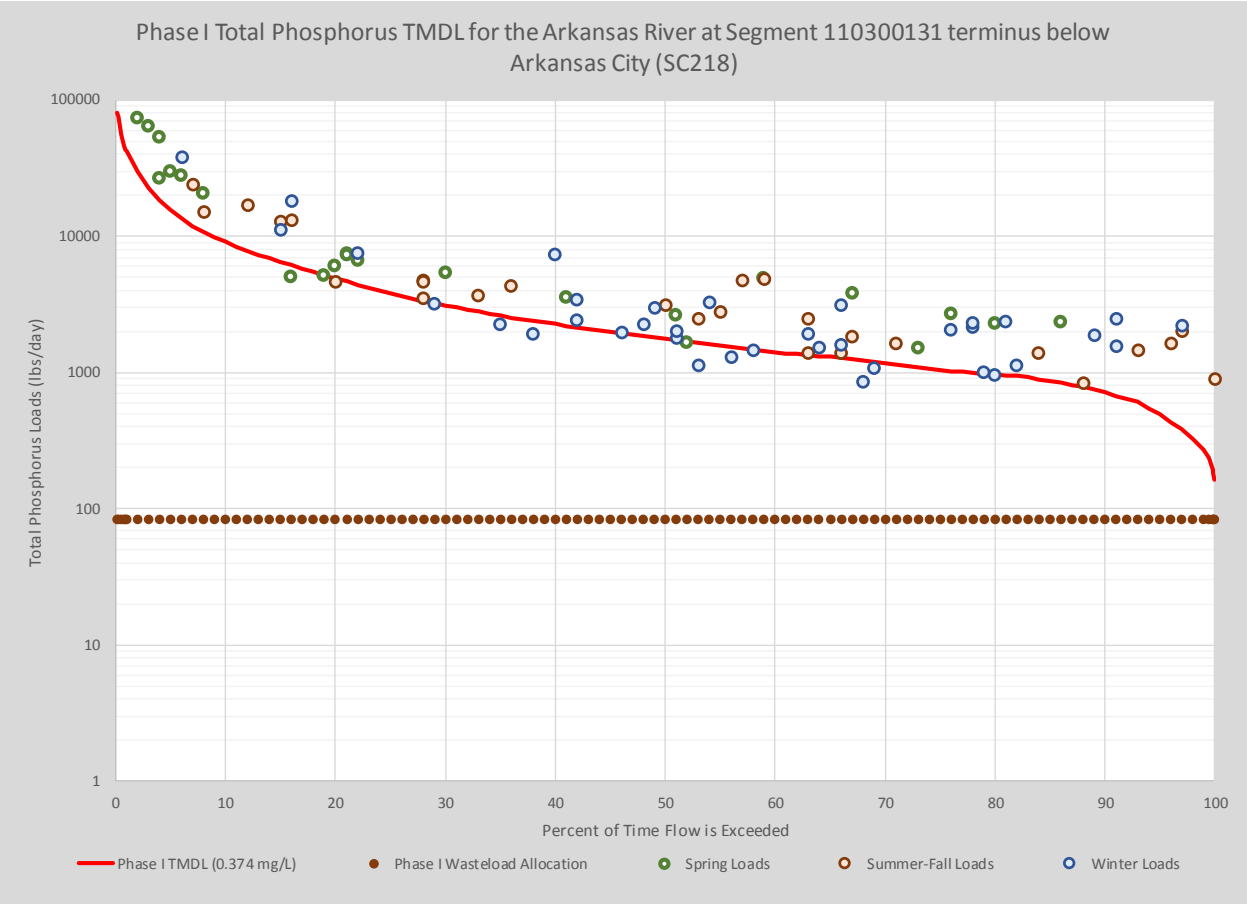


Table 27. Phase I and II load capacity (TMDL), wasteload, and MS4 allocation in the Arkansas River watershed at Arkansas River segment 1 (CUSEGA 110300131) terminus

Percent Flow Exceedance	Flow at terminus (cfs)	Current Condition (lbs/day)	Load Capacity (lbs/day)	Wasteload Allocation (lbs/day)	MS4 Allocations (lbs/day)	Reserve MS4 Allocation (lbs/day)	Reserve Wasteload Allocation (lbs/day)	Load Allocation (lbs/day)
Phase I								
90%	355.41	1049.80	717.78	84.32	1.00	1.00	149.94	481.52
75%	519.60	1534.78	1049.38	84.32	2.00	2.00	149.94	811.12
50%	881.01	2602.33	1779.29	84.32	17.16	76.39	149.94	1451.48
25%	1902.18	5618.66	3841.65	84.32	40.07	178.37	149.94	3388.95
10%	4515.18	13336.94	9118.86	84.32	98.70	439.30	149.94	8346.61
Phase II								
90%	355.41	1049.80	249.50	64.69	1.00	1.00	149.94	32.87
75%	519.60	1534.78	364.76	64.69	2.00	2.00	149.94	146.13
50%	881.01	2602.33	618.47	64.69	5.97	27.39	149.94	370.48
25%	1902.18	5618.66	1335.33	64.69	13.69	62.85	149.94	1044.16
10%	4515.18	13336.94	3169.66	64.69	33.45	153.58	149.94	2768.00

Nonpoint Source Load Allocation: The load allocation for nonpoint sources is the remaining load capacity after wasteloads and reserve wasteloads for NPDES discharging permits and MS4 stormwater have been accounted for in. Nonpoint sources are assumed to be minimal during low flow conditions. The load allocation grows proportionately as normal conditions occur and the load allocation continues to increase with wet weather conditions, thereby accounting for increased runoff from contributing areas. The Phase I and Phase II nonpoint source reductions in phosphorus loading in the Little Arkansas River watershed (SC729) and the Arkansas River watersheds at Wichita (SC729), Derby (SC281), Oxford (SC527) and Arkansas City (SC218) are expected to be achieved by implementation of agricultural best management practices in the watersheds.

MS4 Stormwater: The wasteload allocation for the MS4 stormwater permits in the Little Arkansas and Arkansas River watersheds is provided by proportioning the remaining load capacity, after accounting for the NPDES wasteload allocation, between MS4 and nonpoint source loads. This was done by assuming MS4 load contributions would arise from the developed areas within the contributing areas of the TMDL watersheds. Thus, the MS4 WLA considers the proportion of developed land (open space and low, medium and high intensity) in the contributing areas of SC728, SC729, and SC281, SC527, and SC218 at 24%, 81%, 68%, 10% and 5%, respectively.

The MS4 allocation displayed for the Little Arkansas River watershed (SC728) applies to stormwater permits assigned to the cities of Kechi, Park City, Valley Center and Wichita. The MS4 allocation for the Arkansas River at Wichita (SC729) watershed applies to the Cities of Bel Aire and Wichita as well as the Kansas Department of Transportation (KDOT-Sedgwick County) and Sedgwick County. The MS4 allocation for the Arkansas River watershed from Wichita to Derby (SC281) applies to the City of Wichita, McConnel Air Force Base, Kansas Department of Transportation (KDOT-Sedgwick County) and Sedgwick County. In the Arkansas River watershed from Derby to Oxford (SC527), MS4 allocations apply to the cities of Derby and Mulvane as well as the Kansas Department of Transportation (KDOT-Sedgwick County) and Sedgwick County. And finally, the MS4 allocation for the Arkansas River watershed from Oxford to its confluence with the Walnut River applies to the City of Arkansas City.

Runoff volume during precipitation events in each of the KDHE stream station contributing areas was estimated using Wiki Watershed: Model My Watershed with the precipitation value set at the model's default value of 2.5 cm. The Phase I and Phase II runoff TP loads for each watershed was calculated using the Phase I and Phase II TP milestones for each watershed. These loads were then multiplied by 23%, the percentage of time rain falls in the watershed (NOAA USW00013986 1996-2017) with the resulting load multiplied by the percentage of developed land in the watersheds. The resulting loads Phase I and Phase II loads were then divided by their respective load allocation (load capacity minus wasteload allocation) at 50% flow exceedance and the resulting percentage was applied to the flow curve over the 50% to 0% flows. During both phases, nominal MS4 allocations of 1 lb/day and 2 lb/day for Arkansas River flows ranging from 76 to 100 and 51 to 75 percent flow exceedance, respectively, have been assigned to account for incidences of localized heavy rainfall that may generate runoff conditions when the river is at or below median flow. In addition, a reserve MS4 wasteload allocation has

been established in each TMDL watershed to accommodate growth. MS4 permitees are expected to reduce phosphorus loading using best management practices to the maximum extent practicable.

Defined Margin of Safety: The Margin of Safety provides some hedge against the uncertainty in phosphorus loading into the Little Arkansas and Arkansas Rivers. This TMDL uses an implicit margin of safety, relying on conservative assumptions. Firstly, there are five endpoints that are established by this TMDL. Secondly, the sestonic chlorophyll *a* and biological endpoints used to assess compliance with the narrative criteria have to be maintained for three consecutive years before attainment of water quality standards can be claimed. Third, because there is often a synergistic effect of phosphorus and nitrogen on in-stream biological activity, concurrent efforts by municipal wastewater treatment facilities to reduce nitrogen content of its wastewater should complement the effect of phosphorus load reduction in improving the biological condition of the Arkansas River. In addition, wasteloads were conservatively set by using design flow for municipal facilities although most are discharging well under design flow and some wastewater treatment facilities were assigned wasteloads when it is likely that several do not contribute any nutrient loads. Furthermore, total phosphorus TMDL development for the watersheds of the tributaries to the Lower Arkansas River are scheduled for 2020. Implementation of those TMDLs will support total phosphorus load reductions in the main stem Little Arkansas and Lower Arkansas Rivers.

State Water Plan Implementation Priority: Early implementation of this TMDL will focus on wastewater treatment at the major municipal wastewater treatment facilities in the watershed along with riparian management to effectively reduce the phosphorus loading to the Little Arkansas and Arkansas Rivers. Additionally, further reduction in phosphorus loads will occur along with implementation of stormwater abatement practices. Due to the need to reduce the high nutrient loads in the watersheds, this TMDL will be **High** Priority for implementation.

Nutrient Reduction Framework Priority Ranking: Most of the TMDL watershed lies within the Little Arkansas Subbasin (HUC8: 11030012) or the Middle Arkansas – Slate Subbasin (11030013) which are among the top sixteen HUC8s targeted for state action to reduce nutrients.

Priority HUC12s: Although this TMDL is initially driven by implementation of point source treatment improvements, priority HUC12s within the watershed can be identified based on the cropland areas adjacent to the streams within the watershed. Priority HUC 12s are based on HUC12s with the highest pounds per year per acre of loading as estimated by STEPL (**Table 27**). Priority HUC12s for total phosphorus reduction appear as in **Figure 78** and are identified as: 110300130306; 110300130308; and 110300130305. Although this TMDL does not establish a load reduction for total nitrogen, priority HUC12s for nitrogen reduction have been identified in order to provide Watershed Restoration and Protection Strategy (WRAPS) groups with additional information in targeting areas for nutrient reduction in their watershed. Priority HUC12s for total nitrogen reduction appear as dark green in **Figure 79** with HUC 12s contributing the highest loads of total nitrogen mirroring those identified as high priority for total phosphorus reduction.

Table 27. HUC12 land use and estimated total phosphorus load based on land use. High priority HUC12s for total phosphorus (TP) reduction are highlighted in beige.

HUC 12	Urban	Cropland	Pasture and Grazing Land	Forest	Total	TN	TP	TN	TP	SC Site
	acres					*lbs/year*		*lbs/acre/year*		
110300120502	5,010	6,870	7,616	806	20,303	168,502	29,403	8.30	1.45	SC728
110300120501	2,508	13,034	11,564	904	28,011	248,259	46,012	8.86	1.64	SC728
110300130101	25,202	1,238	4,527	382	31,349	190,919	29,135	6.09	0.93	SC729
110300130106	18,623	1,082	4,334	792	24,830	142,522	21,685	5.74	0.87	SC281
110300130305	486	16,859	7,289	1,650	26,284	273,199	74,447	10.39	2.83	SC527
110300160203	698	23,893	6,147	1,180	31,918	259,115	62,812	8.12	1.97	SC527
110300130304	244	16,633	6,670	1,556	25,103	190,920	44,100	7.61	1.76	SC527
110300130303	1,039	10,042	10,052	2,203	23,337	156,090	31,631	6.69	1.36	SC527
110300130301	3,034	8,968	12,474	1,475	25,952	163,218	29,663	6.29	1.14	SC527
110300130308	115	8,482	4,722	816	14,135	157,555	40,964	11.15	2.90	SC218
110300130307	84	15,541	6,307	681	22,613	198,228	45,843	8.77	2.03	SC218
110300130206	35	20,260	8,172	618	29,085	246,677	58,296	8.48	2.00	SC218
110300130306	66	14,074	4,028	1,647	19,816	228,242	64,435	11.52	3.25	SC218
110300130205	116	13,416	10,895	274	24,701	251,415	50,431	10.18	2.04	SC218

Figure 78. STEPL results for total phosphorus loading in the TMDL watershed.

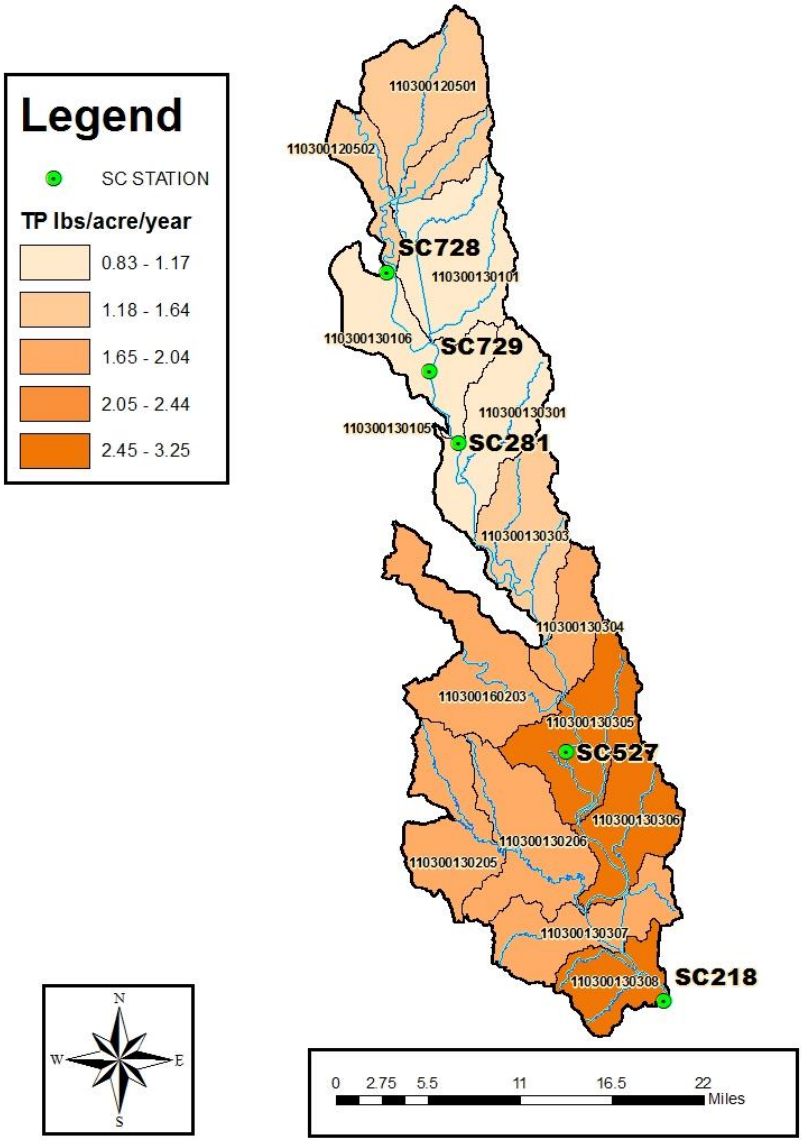
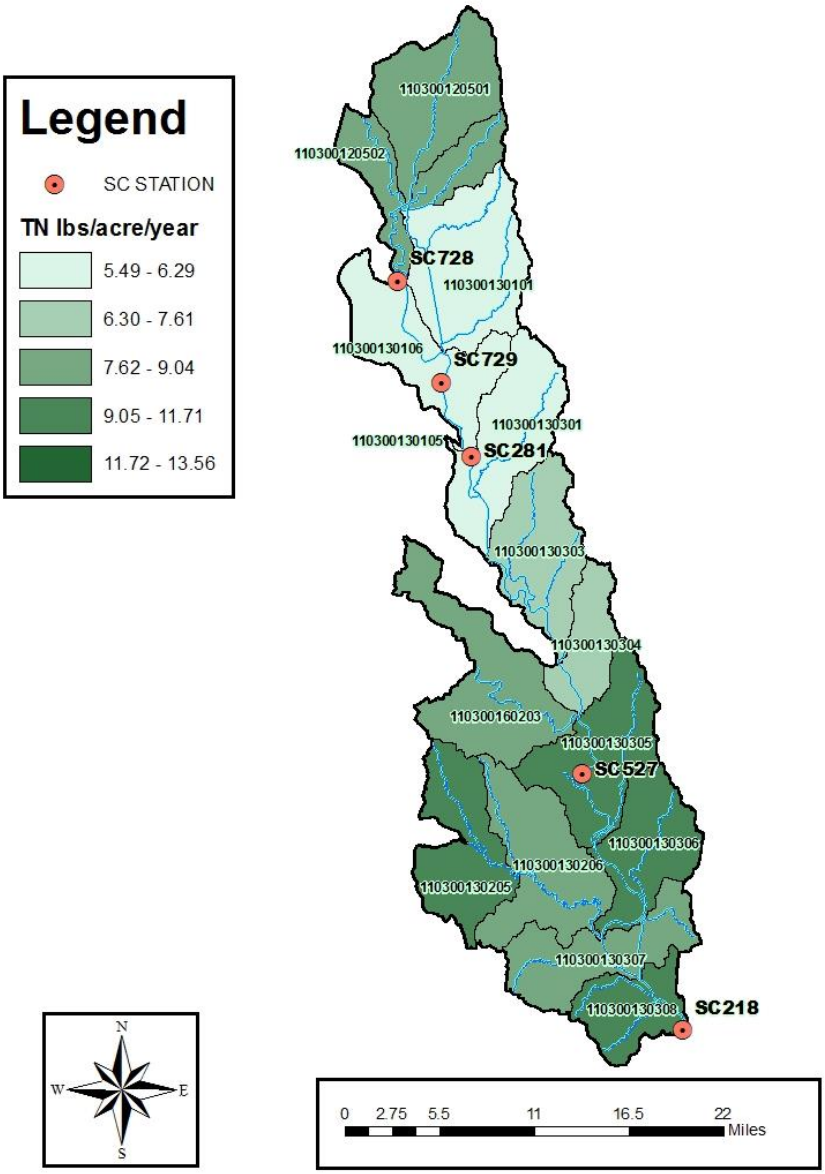


Figure 79. STEPL results for total nitrogen loading in the TMDL watershed.

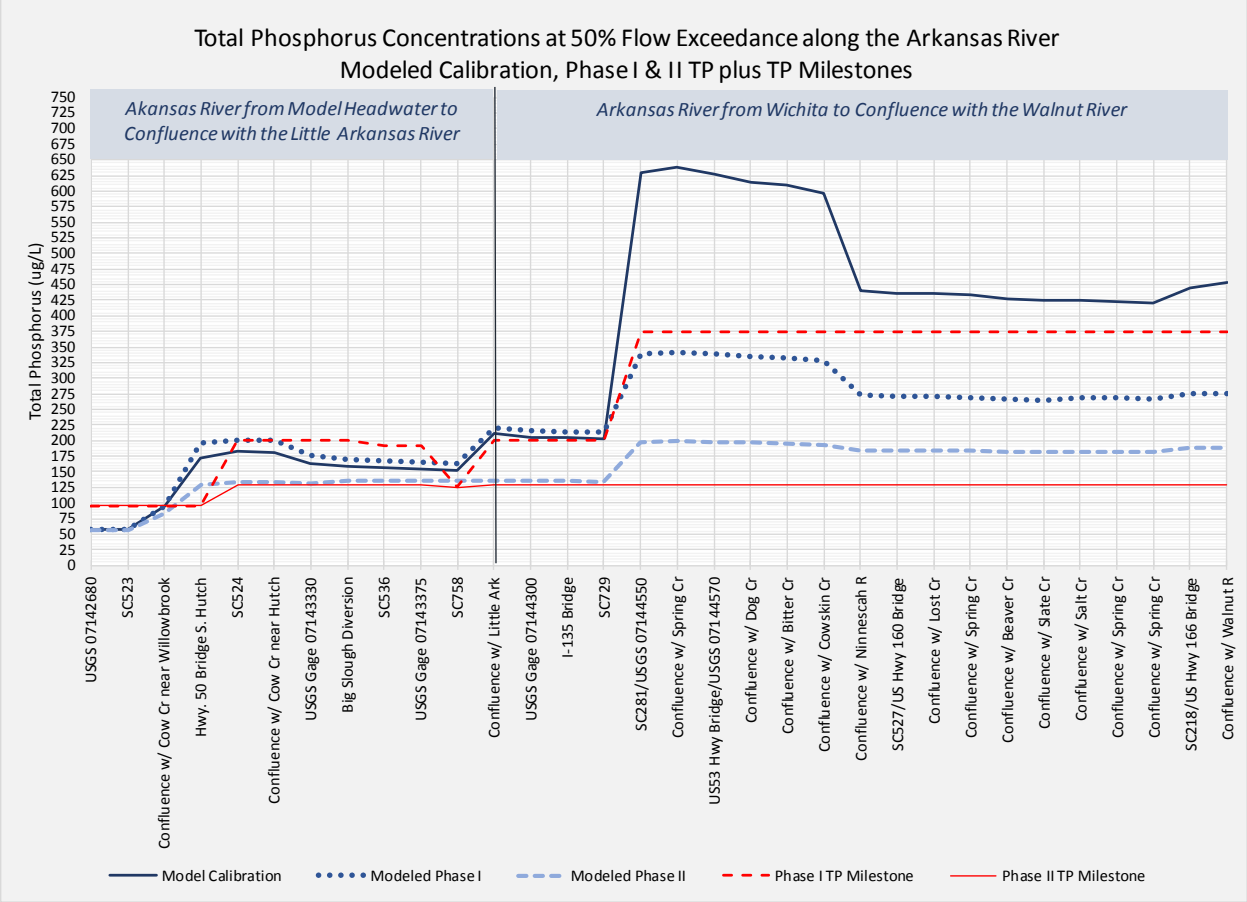


5. IMPLEMENTATION

Point Source Implementation Supporting Information: Qual2k is a steady-state model that was utilized to evaluate total phosphorus responses under the hydrologic flow conditions representing the median or 50th percent flow exceedance condition in the Lower Arkansas River from Nickerson to its confluence with the Walnut River below Arkansas City. The model run during the median flow represents the midpoint of flow conditions in the river where NPDES point source contributions were assessed for their load contributions into the Lower Arkansas River system. The primary purpose of the model was to assess the contribution from discharging point sources.

The modeling assessment concluded that, at median flow condition, the Phase I reductions in wasteload allocations will support the protective TMDL established at Hutchinson (SC523) and are likely to achieve the ecoregional Phase I total phosphorus milestones of 200 μg/L at Yoder (SC524), 192 μg/L at Maize (SC536), 125 μg/L at Wichita (SC758), 374 μg/L in the Little Arkansas River above Wichita (SC729), 200 μg/L in the Arkansas River at Wichita (SC729), and 374 μg/L in the Arkansas River at Derby (SC281), Oxford (SC527) and Arkansas City (SC218). (**Figure 80**). For Phase II, municipal mechanical dischargers were set to an effluent concentration of 500 μg/L at design flow and modeled point-source tributaries with TP concentrations greater than 200 μg/L were reduced to that level in anticipation of future TP TMDL development for those streams. The modeled Phase II reductions demonstrate total phosphorus concentrations in the river should achieve the Phase II milestone of 130 μg/L from Yoder (SC524) to its confluence with the Little Arkansas River at Wichita (SC758). And, to remain consistent with the established methodology of applying lower quartile ecoregional total phosphorus values as management milestones in adaptive management total phosphorus TMDLs, a Phase II milestone of 130 μg/L has been established for the Little Arkansas River at Wichita (SC728) and in the Arkansas River from Wichita (SC729) to its confluence with the Walnut River below Arkansas City. However, during Phase II, the model shows total phosphorus concentrations in the river are strongly influenced by the loads being discharged by major municipal and industrial waste treatment plants along the river from Wichita (SC729) to Arkansas City (SC218). And although the modeled Phase II concentration at the river's confluence with Walnut River is about 190 μg/L, success in meeting the Phase II TP milestones will rely on future TMDL development and implementation as well as a concerted effort between the nonpoint sources, municipal wastewater facilities, and municipal stormwater (MS4) programs in the Arkansas River watersheds.

Figure 80. Total phosphorus concentrations long the Lower Arkansas River at 50% flow exceedance as modeled by Qual2k with approximate, non-equidistant river locations from Nickerson (Headwater) to the its confluence with the Walnut River below Arkansas City.



Desired Implementation Activities

1. Implement and maintain conservation farming, including conservation tilling, contour farming, and no-till farming to reduce runoff and cropland erosion.
2. Improve riparian conditions along stream systems by installing grass and/or forest buffer strips along the stream and drainage channels in the watershed.
3. Perform extensive soil testing to ensure excess phosphorus is not applied.
4. Ensure land applied manure is being properly managed and is not susceptible to runoff by implementing nutrient management plans.
5. Install pasture management practices, including proper stock density to reduce soil erosion and storm runoff.
6. Ensure proper on-site waste system operations in proximity to the main stream segments.
7. Ensure that labeled application rates of chemical fertilizers are being followed and implement runoff control measures.
8. Make operational changes in municipal wastewater treatment plants and implement alternative disposal such as irrigation and, if necessary, install enhanced nutrient reduction technology to reduce wasteloads.

9. Renew state and federal permits and inspect permitted facilities for permit compliance.
10. Facilitate urban and construction stormwater management in Reno and Sedgwick counties, including the cities of Hutchinson and Wichita to abate pollutant loads using best management practices to the maximum extent practicable.
11. The stakeholder leadership team for any active WRAPS group will coordinate best management practices to address:
    a. Livestock: vegetative filter strips, relocate feeding sites, relocate pasture feeding sites off-stream and alternate watering system.
    b. Cropland: waterways, terraces, conservation crop rotations and water retention structures.

NPDES and State Permits – KDHE

a. Monitor influent into and effluent from the discharging permitted wastewater treatment facilities, continue to encourage wastewater reuse and irrigation disposal and ensure compliance and proper operation to control phosphorus levels in wastewater discharges.
b. Establish applicable permit limits and conditions after 2022, with the initial implementation of goals and appropriate schedules of compliance for permits issued prior.
c. Establish TP concentration goal of 1.0 mg/L for all mechanical municipal wastewater treatment facilities in accordance with the WLA.
d. Manage the sum of WLA for the watershed to accommodate population growth as needed.
e. Inspect permitted livestock facilities to ensure compliance.
f. New livestock permitted facilities will be inspected for integrity of applied pollution prevention technologies.
g. New registered livestock facilities with less than 300 animal units will apply pollution prevention technologies.
h. Manure management plans will be implemented, to include proper land application rates and practices that will prevent runoff of applied manure.
i. Reduce runoff in MS4 permitted areas through stormwater management programs.
j. Establish nutrient reduction practices among urban homeowners to manage application on lawns and gardens, through respective stormwater management programs.

Nonpoint Source Pollution Technical Assistance – KDHE

a. Support Section 319 implementation projects for reduction of phosphorus runoff from agricultural activities as well as nutrient management.
b. Provide technical assistance on practices geared to the establishment of vegetative buffer strips.

c. Provide technical assistance on nutrient management for livestock facilities in the watershed and practices geared towards small livestock operations, which minimize impacts to stream resources.
d. Support the implementation efforts of any active WRAPS group in the watershed and incorporate long-term objectives of this TMDL into their 9-element watershed plan.

Water Resource Cost Share and Nonpoint Source Pollution Control Program – KDA-DOC

a. Apply conservation farming practices and/or erosion control structures, including no-till, terraces, and contours, sediment control basins, and constructed wetlands.
b. Provide sediment control practices to minimize erosion and sediment transport from cropland and grassland in the watershed.
c. Install livestock waste management systems for manure storage.
d. Implement manure management plans.

Riparian Protection Program – KDA-DOC

a. Establish or reestablish natural riparian systems, including vegetative filter strips and streambank vegetation.
b. Develop riparian restoration projects along targeted stream segments, especially those areas with baseflow.
c. Promote wetland construction to reduce runoff and assimilate sediment loadings.
d. Coordinate riparian management within the watershed and develop riparian restoration projects.

Buffer Initiative Program – KDA-DOC

a. Install grass buffer strips near streams.
b. Leverage Conservation Reserve Enhancement Program to hold riparian land out of production.

Extension Outreach and Technical Assistance – Kansas State University

a. Educate agricultural producers on sediment, nutrient, and pasture management.
b. Educate livestock producers on livestock waste management, land applied manure applications, and nutrient management planning.
c. Provide technical assistance on livestock waste management systems and nutrient management planning.
d. Provide technical assistance on buffer strip design and minimizing cropland runoff.
e. Encourage annual soil testing to determine capacity of field to hold phosphorus.
f. Educate residents, landowners, and watershed stakeholders about nonpoint source pollution.
g. Promote and utilize the WRAPS efforts for pollution prevention, runoff control and resource management.

Timeframe for Implementation: Reduction strategies for the wastewater treatment facilities should be evaluated by 2020 with subsequent planning, design, and construction of any expanded treatment initiated by the next permit starting in 2022. Urban stormwater and rural runoff management should be expanded in 2018 to ensure nutrients are addressed. Pollutant reduction practices should be installed within the priority subwatersheds before 2023 with follow-up implementation over 2023-2028. Phase I of this TMDL will occur from 2020 to 2040. If biology in the Arkansas River has not responded to Phase I reductions by 2040 then Phase II implementation will commence in 2041.

Targeted Participants: The primary participants for implementation will be municipal wastewater and stormwater programs, and agricultural and livestock producers operating immediately adjacent to the Arkansas River and its tributaries. Watershed coordinators and technical staff of any active WRAPS group, along with Conservation District personnel and county extension agents should assess possible sources adjacent to streams. Implementation activities to address nonpoint sources should focus on those areas with the greatest potential to impact nutrient concentrations adjacent to the river.

Targeted Activities to focus attention toward include:

1. Overused grazing land adjacent to the streams.
2. Sites where drainage runs through or adjacent to livestock areas.
3. Sites where livestock have full access to the stream as a primary water supply.
4. Poor riparian area and denuded riparian vegetation along the stream.
5. Unbufferred cropland adjacent to the stream.
6. Conservation compliance on highly erodible areas.
7. Total row crop acreage and gully locations.
8. High-density urban and residential development in proximity to streams and tributary areas.
9. Urban residents should be informed on fertilizer and waste management through their respective municipal Stormwater Management Programs to reduce urban runoff loads.

Milestone for 2024: By 2024, advancement of necessary and appropriate measures to decrease the effluent phosphorus content from the municipal wastewater facilities should be implemented. At that point in time, phosphorus data from the Arkansas River stream chemistry station SC523 should show no signs of an increase in median concentration and stream chemistry stations SC524, SC536, and SC758 should show indication of declining concentrations relative to the pre-2018 data, particularly during low flow conditions.

Delivery Agents: The primary delivery agents for program participation will be municipalities within the watershed, and KDHE.

Reasonable Assurances:
Authorities: The following authorities may be used to direct activities in the watershed to reduce pollution:

1. K.S.A. 65-164 and 165 empowers the Secretary of KDHE to regulate the discharge of sewage into the waters of the state.
2. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.
3. K.S.A. 2002 Supp. 82a-2001 identifies the classes of recreation use and defines impairment for streams.
4. K.A.R. 28-16-69 through 71 implements water quality protection by KDHE through the establishment and administration of critical water quality management areas on a watershed basis.
5. K.S.A. 2-1915 empowers the Kansas Department of Agriculture, Division of Conservation to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.
6. K.S.A. 75-5657 empowers the Kansas Department of Agriculture, Division of Conservation to provide financial assistance for local project work plans developed to control nonpoint source pollution.
7. K.S.A. 82a-901, et. seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.
8. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the Kansas Water Plan, including selected Watershed Restoration and Protection Strategies.
9. The Kansas Water Plan and the Kansas Regional Action Plans provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority implementation.

Funding: The State Water Plan annually generates $12-13 million and is the primary funding mechanism for implementing water quality protection and pollution reduction activities in the state through the Kansas Water Plan. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watershed and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are located within a **High** Priority area and should receive support for pollution abatement practices that lower the loading of sediment and nutrients.

Effectiveness: Use of Biological Nutrient Removal technology has been well established to reduce nutrient levels, including phosphorus, in wastewater and Enhanced Nutrient Removal, including phosphorus recovery technologies, establishes phosphorus levels approaching pragmatic limits of technology. Additionally, nutrient control has been proven effective through conservation tillage, contour farming and use of grass waterways and buffer strips. In addition, the proper implementation of comprehensive livestock waste management plans has proven effective at reducing nutrient runoff associated with livestock facilities.

6. MONITORING

Future stream chemistry sampling will continue in the Little Arkansas River at Wichita (SC728) and in the Arkansas River at Wichita (SC729), Derby (SC281), Oxford (SC527), and Arkansas City (SC218) with sestonic chlorophyll *a* monitoring occurring at Arkansas City (SC218). Monitoring of tributary levels of TP for streams with existing KDHE monitoring stations will continue. Monitoring of TP should be a condition of the MS4 permits within the TMDL watershed.

Macroinvertebrate sampling will continue in the Little Arkansas River at Wichita at SB728 and in the Arkansas River at Derby (SB281) and Arkansas City (SB218) and possibly at other accessible locations in the river. If the biological endpoints are achieved over 2024-2029, the conditions described by the narrative nutrient criteria will be viewed as attained and the impaired segments of Little Arkansas River as measured at SC728 and the Arkansas River as measured at SC729, SC281, SC527, and SC218 may be moved to Category 2 on the 2030-303(d) list.

Once the water quality standards are attained, the adjusted ambient phosphorus concentrations in the Little Arkansas River at Wichita (SC728) and in the Arkansas River at Wichita (SC729), Derby (SC281), Oxford (SC527), and Arkansas City (SC218) will be the basis for establishing numeric phosphorus criteria through the triennial water quality standards process to protect the restored biological and chemical integrity of the reaches of the Arkansas River.

7. FEEDBACK

Public Notice: An active Internet Web site is established at http://www.kdheks.gov/tmdl/planning_mgmt.htm to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Arkansas River Basin. This TMDL was posted to this site on April 5, 2018 for public review.

Public Hearing: A Public Hearing on this Lower Arkansas River Basin TMDL was held in Wichita, Kansas on April 27, 2018 to receive comments on this TMDL. No comments were received.

Milestone Evaluation: In 2024, evaluation will be made as to the degree of implementation that occurred within the TMDL watershed. Any active WRAPS group in the watershed will be consulted when making subsequent decisions regarding the non-point source implementation approach and follow up of additional implementation in the watershed.

Consideration for 303(d) Delisting: The Lower Arkansas River segments impaired for total phosphorus as monitored at SC728, SC729, SC281, SC527, and SC218 will be evaluated for delisting under Section 303(d) based on the monitoring data over the period 2024-2029. Therefore, the decision for delisting will come about in the preparation of the 2030 303(d) list. Should modifications be made to the applicable water quality criteria during the ten-year implementation period, consideration for delisting, desired endpoints of this TMDL, and implementation activities may be adjusted accordingly.

Incorporation into the TMDL Vision Process, Water Quality Management Plan and the Kansas Water Planning Process: Under the current version of the Kansas TMDL Vision Process, the next anticipated revision would come in 2022, which will emphasize implementation of WRAPS activities and reduction of nutrients in wastewater developed by NPDES facilities. At that time, incorporation of this TMDL will be made into the WRAPS watershed plans. Recommendations of this TMDL will be considered in the Kansas Water Plan implementation decisions under the State Water Planning Process for Fiscal Years 2018-2026.

Developed November 15, 2018

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APPENDIX A. NPDES permitted facilities in the Little Arkansas River watershed from Valley Center to Wichita and in the Arkansas River watershed from Wichita to terminus of segment 110300131, below Arkansas City, with Phase I Wasteload Allocations.

Permitee	NPDES Permit #	KS Permit #	Type	Permit Expires	SC Site	Design Flow (MGD)	Anticipated TP Concentration (mg/L)	TP WLA Daily Load (lbs/day)	TP WLA Annual Load (lbs/year)
Country Acres Trailer Court	KSJ000555	C-LA16-NO01	Non-discharging Lagoon	11/30/20	SC728	0	n/a	0	0
North Star RV Park & Mobile Home Community	KSJ000174	C-LA16-NO03	Non-discharging Lagoon	10/31/20	SC728	0	n/a	0	0
Kice Industries, Inc.	KSP000101	P-LA19-OO02	Industrial Pretreatment	12/31/20	SC728	n/a	n/a	n/a	n/a
Chisholm Creek Utility Authority	KS0089176	M-LA19-OO02	Municipal Mechanical WWTP	11/30/20	SC728	2.16	1	18.0	6586.1
City of Valley Center	KS0099074	M-LA16-OO02	Municipal Mechanical WWTP	10/31/20	SC728	0.7	1	5.8	2134.4
Andale Ready Mix	KSG110165	I-AR94-PR09	Ready Mix Plant	9/30/22	SC729	*	0	0	0
CMC Plant 1 - South Madison Plant	KSG110210	I-AR94-PR16	Ready Mix Plant	9/30/22	SC729	*	0	0	0
VMC	KSG110173	I-AR94-PR10	Ready Mix Plant	9/30/22	SC729	*	0	0	0
Wichita Concrete Pipe Company	KSG110199	I-AR94-PR12	Ready Mix Plant	9/30/22	SC729	*	0	0	0
Friends University	KS0088803	I-AR94-CO47	Industrial Non-Contact Cooling	12/31/22	SC729	0.0288	0.2	0.05	17.56
Hospitality Real Estate Corporation	KS0099651	I-AR94-PO08	Industrial Non-Contact Cooling	11/30/22	SC729	0.0011	0.2	0.00	0.67
Lubrication Engineers		I-AR949PO08	Industrial Non-Contact Cooling	11/30/19	SC729	0.024	0.2	0.04	14.64
The Coleman Company, Inc. - Northeast Plant	KS0054267	I-AR94-CO10	Industrial Non-Contact Cooling	12/31/17	SC729	0.018	0.2	0.03	10.98
Boeing Wichita - Groundwater Remediation Project	KS0088757	I-AR94-PO46	Groundwater Remediation	12/31/18	SC729	0.169	0.2	0.28	103.06
El Paso Merchant Energy	KS0092118	I-AR94-PO78	Groundwater Remediation	12/31/18	SC729	0.0144	0.2	0.02	8.78
Koch-Glitsch Groundwater Remediation	KS0099805	I-AR94-PO06	Groundwater Remediation	8/31/19	SC729	0.0864	0.2	0.14	52.69
Gilbert & Mosley Remediation Site	KS0092762	I-AR94-PO80	Groundwater Remediation	5/31/19	SC729	1.325	0.34	3.76	1373.64
New Coleman Holdings, Inc.	KS0000850	I-AR94-PO21	Groundwater Remediation	7/31/18	SC729	0.5	0.2	0.84	304.91
The Coleman Company, Inc. - Factories A and B	KS0091855	I-AR94-PO76	Groundwater Remediation	12/3122	SC729	0.1728	0.2	0.29	105.38

Permitee	NPDES Permit #	KS Permit #	Type	Permit Expires	SC Site	Design Flow (MGD)	Anticipated TP Concentration (mg/L)	TP WLA Daily Load (lbs/day)	TP WLA Annual Load (lbs/year)
The Coleman Company, Inc. - Northeast Groundwater Remediation	KS0091421	I-AR94-PO70	Groundwater Remediation	11/30/22	SC729	0.2304	0.2	0.38	140.50
Union Pacific Railroad Hydraulic Containment System	KS0099970	I-AR94-PO12	Groundwater Remediation	3/31/19	SC729	0.144	0.2	0.24	87.82
Beechcraft Corporation	KS0000183	I-AR94-PO04	Industrial Non-Contact Cooling & Groundwater Remediation	12/31/18	SC729	0.082	0.2	0.14	50.01
Cessna Aircraft Company - Pawnee Facility	KS0000647	I-AR94-PO05	Industrial Non-Contact Cooling & Groundwater Remediation	1/31/17	SC729	0.2076	0.28	0.49	177.24
Spirit Aerosystems, Inc	KS0000396	I-AR94-PO20	Industrial Mechanical Waste Treatment	12/31/13	SC729	1.8	0.2	3.01	1097.69
The Mann Cave	KSJ000165	C-AR94-NO21	Non-discharging Lagoon	11/30/18	SC281	0	n/a	0	0
CMC - West Robbins Plant	KSG110034	I-AR94-PR07	Concrete operation	9/30/22	SC281	*	0	0	0
Leading Technology Composites	KS0089010	I-AR94-CO50	Industrial Non-Contact Cooling	12/31/22	SC281	0.02	0.2	0.03	12.20
Wescon Plastics, LLC	KS0000825	I-AR94-PO62	Industrial Non-Contact Cooling	11/30/22	SC281	0.36	0.2	0.60	219.54
Air Capital Flight Line, LLC	KS0098205	I-AR94-PO90	Groundwater Remediation	12/31/13	SC281	0.086	0.2	0.14	52.45
Globe Engineering Company	KS0086703	I-AR94-PO31	Groundwater Remediation	9/30/22	SC281	0.262	0.2	0.44	159.77
McConnell Air Force Base	KS0086452	F-AR94-PO25	Groundwater Remediation	4/30/21	SC281	0.064	0.2	0.11	39.03
City of Wichita - Lower Arkansas River Plant	KS0043036	M-AR94-IO01	Municipal Mechanical WWTP	11/30/22	SC281	54	1	451.11	164653.40
Calvary Baptist Church	KSJ000114	C-AR29-NO04	Non-discharging Lagoon	10/31/18	SC527	0	n/a	0	0
Fairway Meadows	KSJ000434	M-AR94-NO05	Non-discharging Lagoon	12/31/18	SC527	0	n/a	0	0
Prairie Schooner Mobile Home Park	KSJ000603	C-AR64-NO01	Non-discharging Lagoon	3/31/18	SC527	0	n/a	0	0
Long Branch Mobile Home Park	KS0093823	C-AR94-OO07	Discharging lagoon	6/30/22	SC527	0.0167	2	0.28	102.15
City of Derby	KS0050377	M-AR29-OO02	Municipal Mechanical WWTP	10/31/22	SC527	2.5	1	20.88	7622.84

Permitee	NPDES Permit #	KS Permit #	Type	Permit Expires	SC Site	Design Flow (MGD)	Anticipated TP Concentration (mg/L)	TP WLA Daily Load (lbs/day)	TP WLA Annual Load (lbs/year)
City of Mulvane	KS0098418	M-AR64-OO02	Municipal Mechanical WWTP	12/31/19	SC527	1	1	8.35	3049.14
Camp Quaker Haven	KSJ000597	C-AR06-NO03	Non-discharging Lagoon	8/31/18	SC281	0	n/a	0	0
City of Arkansas City	KS0094706	I-AR06-PO10	Water Treatment Plant	8/31/21	SC281	0.024	0.2	0.04	14.64
City of Geuda Springs	KS0116807	M-AR36-OO01	Discharging lagoon	6/30/22	SC281	0.01392	2	0.23	84.89
City of Oxford	KS0028011	M-AR68-OO01	Discharging lagoon	6/30/22	SC281	0.181	2	3.02	1103.79
Creekstone Farms Premium Beef, LLC	KS0094706	I-AR06-PO06	Industrial mechanical WWTP	12/31/18	SC281	1.25	4	41.77	15,246.05
City of Arkansas City	KS0044831	M-AR06-IO01	Municipal Mechanical WWTP	12/30/22	SC281	4.7	1	39.26	14330.94